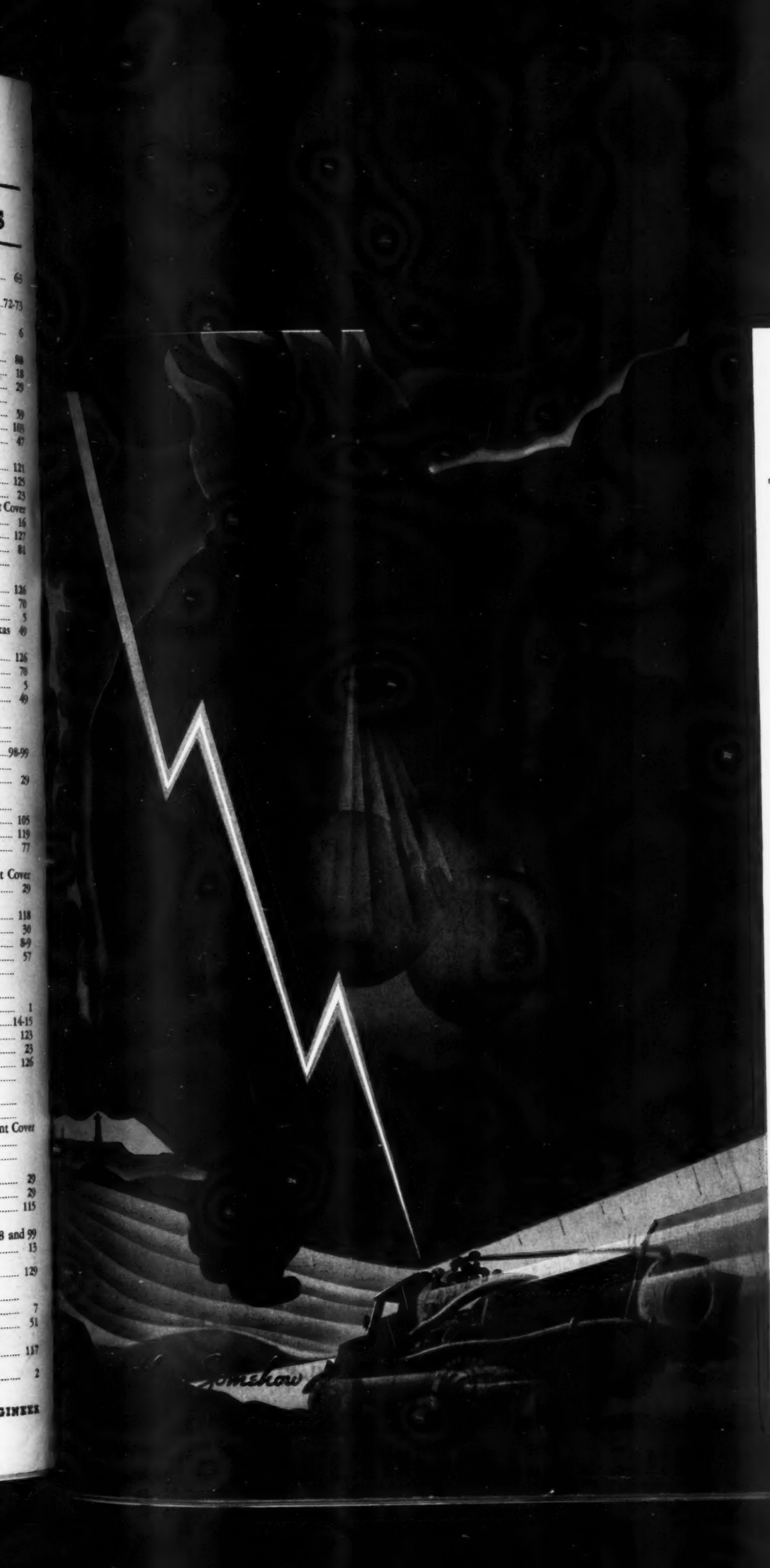

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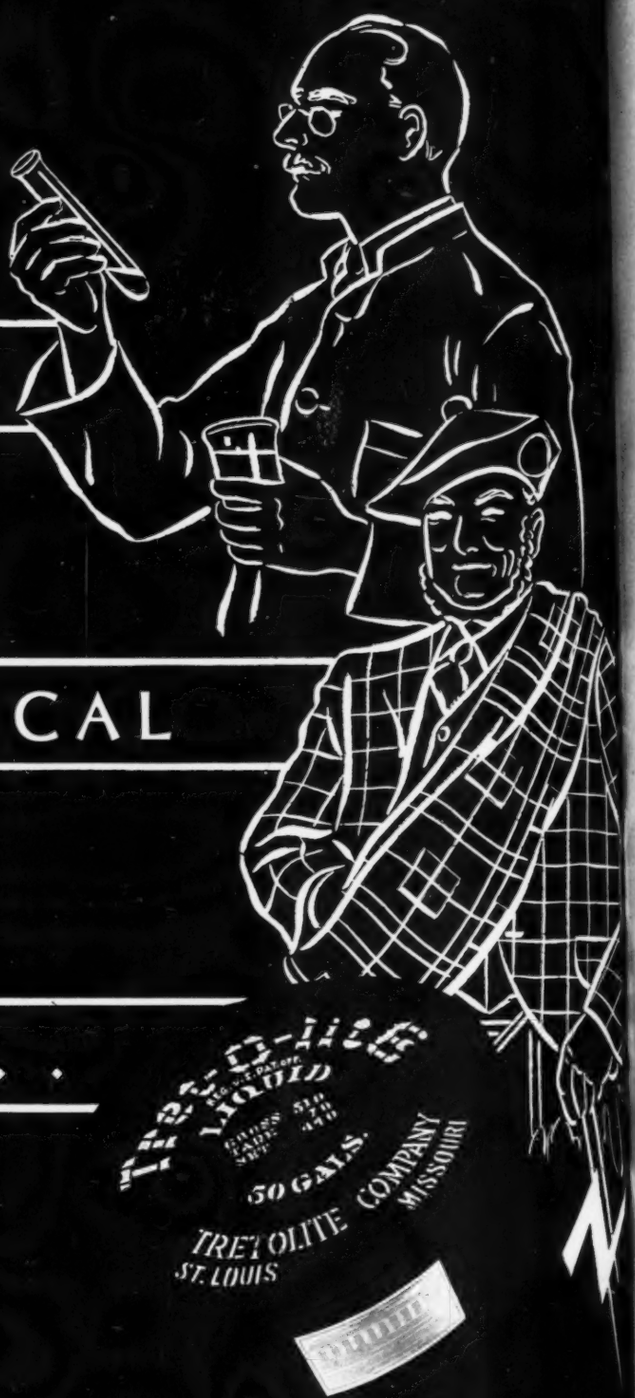

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THE Petroleum Engineer

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A MAGAZINE OF METHODS FOR OPERATING MEN

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The Course of Oil

By K. C. SCLATER

Modern Petroleum Prospecting

Petroleum prospecting methods are rapidly changing. This is inevitable. The search for oil is becoming ever wider and ever deeper. Most significant is the application of geophysics to the search for geologic structure favorable to the accumulation of petroleum. The absence of surface evidence is no longer a worry to the petroleum geologist. Other branches of science have come to his aid. He is now guided in his subsurface studies by the work of the geophysicist. By "sounding" the crust of the earth the geophysicist not only can detect the presence of deeply buried cap rock, but also can determine its form, whether favorable for oil accumulation. Petroleum prospecting thus has taken on a new interest and has become a highly scientific procedure that requires the services of specialists. So important indeed has this new aid become in prospecting for oil that few deep drilling campaigns are launched unless supported by the findings of the geophysicist.

Scientific aids also are employed in drilling. No longer does the wildcatter place dependence solely on the examination of drill cuttings to determine the types and thicknesses of strata penetrated. Coring now is freely resorted to. Not only that, information obtained from cores is supplemented and checked by electrical logs. Holes are surveyed by electrical means, the procedure involved in which is of a highly scientific nature that also calls for the services of specialists.

In the search for oil-bearing strata even the driller now has scientific aids at his disposal. The hole can be deflected in any desired direction underground. One or more such holes may be deflected from the original hole and a likely oil-bearing formation penetrated at any predetermined point so that its character and disposition can be more accurately determined.

All these aids are brought into play in modern petroleum prospecting methods. They will play an increasingly important role as time goes on. In view of this fact, a section in this issue is devoted to this subject. Particularly is the subject of geophysics, and the principles and application of the various geophysical methods and equipment in successful use, discussed in a manner that will appeal to our readers seeking enlightenment on the development, and the present and probable future status, of geophysics as applied to petroleum prospecting.

Determination of Potentials

A great divergence of opinion still prevails regarding the determination of potentials. One who has given much thought to this subject is struck by the confusion, even among engineers, concerning the basis on which the potential of a well should be determined for purposes of proration. The prime purpose of proration is to give to each producer his just share of oil, gas, and gas energy in the reservoir. This being so, a permanent solution to the problem of equitable allowables must be based on and recognize this fact. Only by maintaining the reservoir conditions as nearly uniform as practicable can each producer be assured of receiving his equitable share of the reservoir contents. Too often arguments defending a method of determining potentials are influenced by other considerations that should have little or no bearing on the method employed to arrive at a just allowable for a well.

Enough evidence is available to show that the greatest benefits to all producers in a pool result when uniform reservoir conditions are maintained. Despite this fact arguments still are being set forth based on the premise that the allowable of a well should be based on the capacity of the well to produce. Maintenance of uniform reservoir conditions—not the capacity of a well to produce—is the only justifiable and practicable basis on which a well's potential should be determined for purposes of arriving at equitable allowables. There is a vast difference between these two bases, and recognition of this fact should always be borne in mind when potentials or allowables are under consideration.

International Oil Operations

It is reported that oil concessions have been granted provisionally in Iran and Afghanistan to two subsidiaries of the Seaboard Oil Company of Delaware. The Iran concession comprises 100,000 square miles in Khorassan and Eastern Manzanderan; that in Afghanistan 270,000 square miles. A project of this magnitude promises to change the world picture of oil-producing operations should valuable deposits of petroleum be discovered.

Among the provisions are that prospecting in Iran must begin within six months and prospect wells within eighteen months. Two areas for exploitation must be selected within three years and these may be exploited within five years up to a maximum of 100,000 square miles for which the minimum annual royalties will begin at one and a half million dollars and increase to three million after a period of fifteen years. Such royalties begin five years after ratification of the concession. These figures are ample evidence that operations will be prosecuted vigorously.

In Afghanistan the concession will be for a period of seventy-five years. The Inland Exploration Company, the subsidiary holding this concession, obligates itself to bring the production to 14,000,000 barrels yearly ten years from the date of ratification.

In addition to exploitation of these concessions a pipe line more than a thousand miles long will be laid to Chabbar in the Arabian Sea.

One stipulation in the Afghanistan concession is that the company and project must be entirely American and retain its nationality throughout. American methods and equipment therefore are likely to be employed in these undertakings. All the negotiations in this vast project thus far point to a concerted effort to carry on a vigorous campaign of development.

« « HIGHLIGHTS IN OILDOM » »

General Advance in Crude Oil Prices

Led by the Humble Oil and Refining Company, major crude oil purchasers at last have reached an agreement and, on January 28, put into effect a price advance for the Mid-Continent averaging 12 cents a barrel. Following the Humble's announcement other companies quickly met the schedule of prices, and the Continental Oil Company, which earlier in the month had advanced its purchasing price 17 cents a barrel, dropped back and adopted the more popular level. Nor was the advance confined to the Mid-Continent area. Purchasers in other oil-producing states were not long in posting higher crude prices also, 13 states eventually being affected. Pennsylvania grade fields previously had experienced a price advance. Only the Appalachian and California districts are now without a recent price advance.

●

Development State-Owned Oil Lands

One of the bills now before the California State Senate relates to the development of state-owned oil lands. Senator Olson introduced the bill, which declares that state-owned oil deposits in the Huntington Beach areas are being drained by wells drilled on adjacent lands. It provides for the director of finance to develop state lands in the following manner: acquisition of easements and rights-of-way desirable for access to state lands by proceedings of eminent domain, declaring such acquisition a public necessity, the director of finance being empowered to assign such easements to those who would develop the state lands.

The Huntington Beach tideland area, under terms of the bill, is divided into nine parcels, each to be offered for lease to the highest bidder, based on percentage royalty, provided no two parcels shall be leased to the same person. It also provides that no bid shall be accepted and no lease shall be granted unless a royalty of more than 30 percent is offered. Ten-year leases would be granted, with the right of renewal so long as oil is being produced, not, however, to exceed 25 years. Ten wells would be required for each of the nine parcels of land. Provision also is made for the drilling of submerged lands, and rules relative to prohibition of pollution are set forth. The bill provides that should the director of finance fail to receive bids of sufficient merit he shall, with the consent of the governor, proceed to develop the lands on behalf of the state.

●

New Spacing Rule For Michigan

Development of gas fields in Michigan on the basis of one well to each 160 acres is authorized by revised regulations announced by the Michigan Public Utilities Commission. The first field to be developed on the new spacing pattern is a new shallow sand field in Muskegon County.

●

Oil Drilling In Yorkshire, England

Following prolonged geological investigations the D'Arcy Exploration Company, subsidiary of the Anglo-Iranian Oil Company, proposes to begin drilling for oil at Aislaby, near Whitby, Yorkshire, about March. The company holds nine prospecting licenses in that part of the country, covering an area of approximately 160 sq. miles each. Initial drilling will be in the most northerly area where arrangements already have been completed with the landowners. This well will test the Permian formation. Conditions at Aislaby are somewhat similar to those at Volkenroda, Germany, where oil is being produced.

Proration Lifted From 19 Pools In Oklahoma

Proration regulations on 19 pools of the Greater Seminole (Oklahoma) field have been lifted, according to the Oklahoma Corporation Commission's recent allowable orders. These class B areas, having a potential of 245,720 bbl. daily, with few exceptions are being permitted to produce their normal output of 124,166 bbl. daily. In the group are: Allen, West Allen, Asher-Wanette, Earlsboro pools, Fish (Cromwell), Fish (Wilcox), Grayson, Keokuk Falls, Konawa, Little River, East Little River, Maud, Mission, Olympic, Sasakwa, Sasakwa townsite, North Searight, Searight, Seminole City, Seminole proper, and St. Louis.

The exceptions are Keokuk Falls, which will be allowed 11.5 percent of its potential, or 6101 bbl. daily; Olympic, 33 percent, or 7200 bbl.; Sasakwa townsite, 35 percent, or 655 bbl.; North Searight, 80 percent, or 2703 bbl.; and, Polo, 13 percent, or 2766 barrels.

●

Texas Given Setback in Gas Waste Fight

Natural gas proration orders of the Texas Railroad Commission, aimed at the prevention of gas waste in the Panhandle area by seeking to require ratable purchase, have been declared invalid by the United States Supreme Court. The high court rendered its decision in passing upon a previous decision of a three-judge Federal Court in Texas, which had granted an injunction to the Consolidated Gas Utilities Corporation and the Texoma Natural Gas Company against enforcement of the Railroad Commission's orders issued under authority of House Bill No. 266. The decision of the Federal court was upheld.

The opinion of the Supreme Court, read by Justice Brandeis, said that body assumed gas proration orders to prevent waste could be upheld but said operations of the two companies involved "are neither causing nor threatening any overground or underground waste."

The opinion of the court said further: "The order disables the plaintiffs from performing their contracts except by means of purchases. Resort to these means necessarily results in depriving the plaintiffs of property. Under each statute, if obeyed, the State takes from the pipe line owner the money with which the purchase is made, the money lost through curtailed use of properties developed at large expense, the money lost because of the drainage away from his land of the gas which he is forbidden to produce for himself but must buy from those toward whose lands it migrates.

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Texas officials contended both in lower courts and in the Supreme Court that the Railroad Commission's order setting up the proration program would stop the waste of millions of cu. ft. of gas that previously had been permitted to escape into the air or had been burned. They asserted also that the order was promulgated for protection of correlative rights of owners in a common gas pool and was so applied.

The lower court had maintained that the legislation was intended to provide a market for owners of gas wells who could not sell their product by forcing the major pipe line companies to reduce their production and buy from the others who had no pipe line outlets to available markets.

Following the decision, officials at Austin were uncertain of what steps they would take. The consensus seem to be, however, that the Supreme Court's opinion would be thoroughly analyzed in an effort to determine if a valid order can be written. Legislators from the Panhandle stated they might seek a new law if it were needed and if the opinion indicated a constitutional statute were possible.

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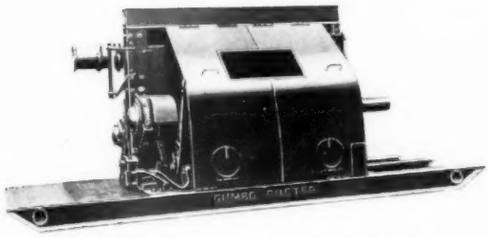

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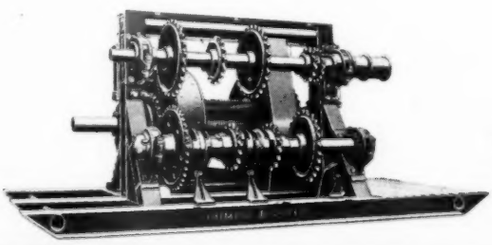

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Progress of Major Pipe Line Work

A NEW compressor station with three 800-b.hp. Cooper-Bessemer units, or an installed capacity of 2400 b.hp., will be erected near Mason City, Iowa, as a part of the Northern Natural Gas Company's rather extensive construction program scheduled for 1937, it has been announced from headquarters at Omaha, Nebraska. Another compressor station will be erected near Walnut, Iowa. At the latter point two 900-b.hp. Worthington units will be installed. Other work contemplated by the Northern Natural includes the addition of one 1300-b.hp. Worthington unit to its compressor station near Bushton, Kansas; and the laying of 20 miles of 20-in. pipe line to partly loop its existing 24-in. line north of Clifton, Kansas.

●

The Gulf Refining Company, Pipe Line Division, has begun the laying of 32 miles of 8-in. line between the Rodessa field and Lufkin, Texas, for the purpose of lessening line pressure and increasing capacity on the existing 6-in. line, which it will loop. The new line, in two loops, will extend from Chatterton, the Gulf's tank station near Lotta in northeast Harrison County, to the company's booster station south of Waskom, and from this booster station to another station south of Carthage. The contract was let to the Latex Construction Company.

It is stated also that Gulf will install new pumping units at the Potter Station, ten miles west of Mooringsport, Louisiana, at Waskom, and at Carthage.

●

The Humble Pipe Line Company has taken over the Amerada Petroleum Corporation's gathering system in the Pearsall field, Frio County, Texas, and will lay a line from that field to Lytle, a distance of 32 miles, where it will tie into its trunk line from West Texas.

●

F. (Dee) Davenport of Mission, Texas, and Charles F. Urschel of Oklahoma City, Oklahoma, are reported to be interested in constructing a pipe line originating in Central Starr County, Texas, and extending to tidewater at Brownsville. The distance is 100 miles. Davenport has applied to the Hidalgo County Commissioner's Court for a permit to use the county right-of-way for the line. The line would originate on the Slick ranch in Starr County, extend to Monte Carlo, thence to the Engleman tract, to the Mercedes field, and to Brownsville. The line primarily would handle high gravity crude, it is understood.

●

The Phillips Petroleum Company will lay a 30-mile 24-in. gas line from the sour gas field of northern Moore County, Texas, to Sanford, Hutchinson County, where it will connect with the company's Rock Creek gasoline plant. The line will be a part of a trunk system that supplies all Phillips gasoline plants south of the Canadian River in Hutchinson County, as well as the carbon black plant Phillips is now constructing in Moore County in conjunction with the United Carbon Company.

It is announced also that Phillips has awarded a contract to J. F. Pritchard and Company for the laying of an extensive gas gathering system in the Eunice field of New Mexico. The system will deliver gas to the natural gasoline plant at Eunice. The lines will vary in size from 3 in. to 20 inch. Work started on this latter project January 30th.

●

Truman Smith Construction Company of Eldorado, Kansas, has been awarded a contract by the Skelly Oil Company for laying a 20-mile extension west from their 6-in. line at Lorraine, Kansas. Seamless pipe in 40-ft. lengths will be used and all joints will be oxy-acetylene welded by the Lindeweld method.

●

The Atlantic Pipe Line Company has let a contract to the Oklahoma Contracting Company, Dallas, Texas, for construction of a 6-in. line from Hobbs, New Mexico, to the Eunice pool, a distance of 16 miles. At Hobbs the new line will tie into the company's Hobbs-to-Midland 8-in. line. The line is being electric welded.

●

The Shell Pipe Line Corporation is enlarging its three main line pumping stations between Longview and Houston, Texas, and erecting three intermediate stations, to take care of an increased movement of Rodessa crude. The stations, of the electrical type, will be enlarged from 600 hp. to 900 horsepower. The new stations will be of 1500 hp., with 500 hp. being used as standby. They will be of the electrical type also.

●

A contract has been let to the B. and M. Construction Company of Oklahoma City, Oklahoma, by the Pure Oil Company for construction of a 4-in. line from Edmond to Oklahoma City, a distance of 14 miles. The line will be oxy-acetylene welded by the Lindeweld method, all joints being bell-hole welded.

●

A 15-mile gas line has been laid from the Stroube and Stroube lease in the North Cayuga area of Southwestern Henderson County to the American Liberty and Tom F. Hunter No. 1 Cage test in the Blackfoot community, near Athens, Texas.

●

The Pure Transportation Company will lay a gathering system to serve the Buckeye Township field, Gladwin County, Michigan, according to a recent announcement. The company is completing construction of a 13-mile line from the new Sherman Township field in Isabella County to Mount Pleasant.

●

The White Deer Pipe Line Construction Company will lay for the Anderson Pritchard Oil Company a 4-in. oil line from a point near Moore, Oklahoma, in the new McClain County field to the Anderson Pritchard booster station southeast of Oklahoma City, a distance of 12 miles. The line will be oxy-acetylene welded.

●

The Wellington Oil Company's well that has just opened the London pool in Nueces County, Texas, has been given an outlet by The Texas Pipe Line Company. A 7-mile 6-in. line has been laid to connect with The Texas Pipe Line Company's system in the Baldwin and Saxet fields in the same county.

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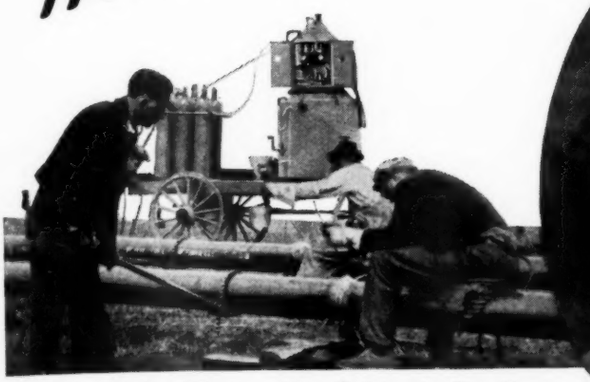
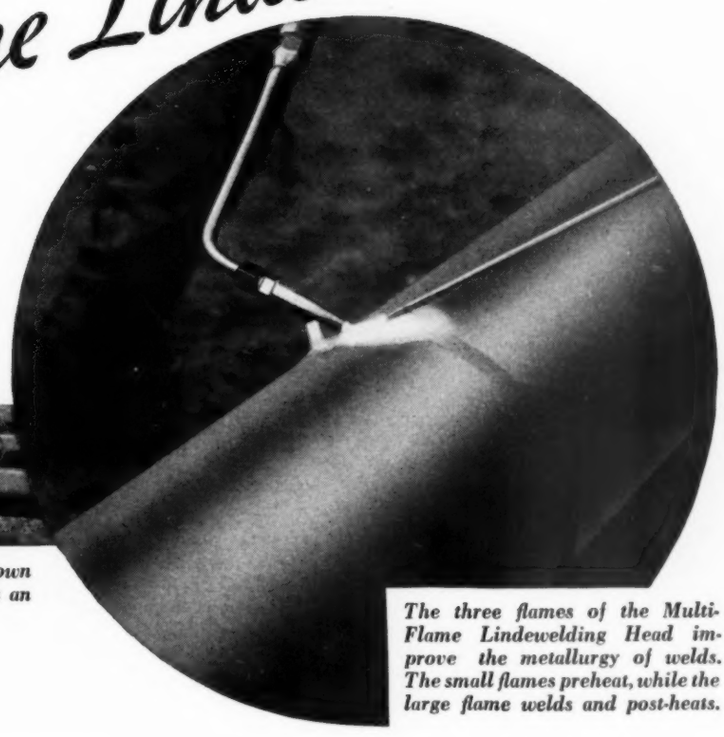


Multi-Flame Lindewelding on a 143-mile 8 in. pipe line. Shown on the gas wagon with the cylinders of Linde Oxygen is an Oxweld Type MP-4 Acetylene Generator.



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Latest Activities In The Oil Fields

FLESCH, Hootkins, Holcomb and Thomason's No. 1 Henderson, brought in as a producer in Marion County, Texas, may prove to be either a 14-mile extension to the Rodessa field, or may be found to be producing from an entirely different structure. That the latter may be true is indicated by difference in the gravity of the crude, that in the Marion County well being 39 deg. A. P. I.

The well was drilled to 6408 ft., plugged back to 5985 ft., and casing perforated at 5996 feet. Initial flow was through open casing at the rate of 50 to 60 bbl. an hour.

●

Two new fields are in prospect for California as a result of wildcat showings. No. 3 S. P. of the Western Gulf Oil Company in the Cantua district of Fresno County, drilled to 8530 ft. and whipstocked to 8500 ft., cored 70 ft. of oil sand showing a good cut and accompanied by strong gas pressure.

Barnsdall Oil Corporation's No. 1 San Francisco in the Newhall district of the Los Angeles Basin, after being drilled to a total depth of 6215 ft., cored 55 ft. of Miocene oil sand.

●

Two discoveries recently were made in Oklahoma areas. In Lincoln County a pool was opened by the Summit Drilling Company and Tom D. Phillips with their No. 1 Eakers. The well, drilled to a total depth of 5140 ft., was treated with 2000 gal. of acid, after which it swabbed 265 bbl. of oil. Production is from limestone formation.

The other discovery was in Seminole County when Phillips Petroleum Company completed their No. 1 Townsend in the Wilcox sand at a total depth of 4221 feet. A good showing of oil was obtained.

●

Considerable interest has been created in the Illinois area by the first important discovery in several years. The Adams-Louisiana Company and the Felmont Corporation successfully completed No. 1 Merryman, 12 miles south of Vandalia in Marion County. The well was drilled to a total depth of 1418 ft., and production was estimated at 600 to 700 bbl. daily. Nearest production is seven miles south in the Sandoval field.

Recovery of saturated cores at 2323-35 ft. in the test being drilled by the Conway Oil Company on the Dewey Dome structure of Weston County, Wyoming, has given operators hope of opening a new field. If it comes in a producer it will be the first strike of 1937 for the Rocky Mountain area.

●

Skelly Oil Company's No. 1 Kipp, southwest of St. John, Kansas, has opened a new pool for Stafford County. On the initial test it made 860 bbl. of oil in 16 hours, producing from the Lansing lime at a total depth of 3906 feet. After being acidized it flowed 1265 bbl. of 33-gravity oil in 24 hours.

Barton County also was given a new pool when Schoenfeld and Ketch et al's No. 1 Winget, six miles west of Galatia, produced 797 bbl. of oil on a 24-hour test from a total depth of 3247 feet.

●

Magnolia Petroleum Company's No. 1-G State, a semi-wildcat 12 miles southeast of Lovington, New Mexico, was shut down for a casing job after encountering 200 ft. of oil in the hole. The total depth of the test is 4450 feet. This is the second well in this isolated area, but it is approximately a mile from the first, No. 1 State-Bridges of the Magnolia Petroleum Company.

●

Tide Water Associated Oil Company's No. 2 Manhattan Fruit Company, on the old Venice Dome, Plaquemines Parish, has cored seven ft. of oil sand and may open a new field for the Gulf Coast of Louisiana. The cores were taken from 6429 to 6436 ft. in Miocene formation.

●

The Wellington Oil Company has made a discovery with its No. 1 Stockton that may prove to be of major importance. This well, approximately 12 miles southwest of Corpus Christi, Texas, in Nueces County, was brought in from a total depth of 4700 ft., being plugged back to that depth from 7005 feet. The well flowed at the rate of 12½ bbl. of oil an hour.

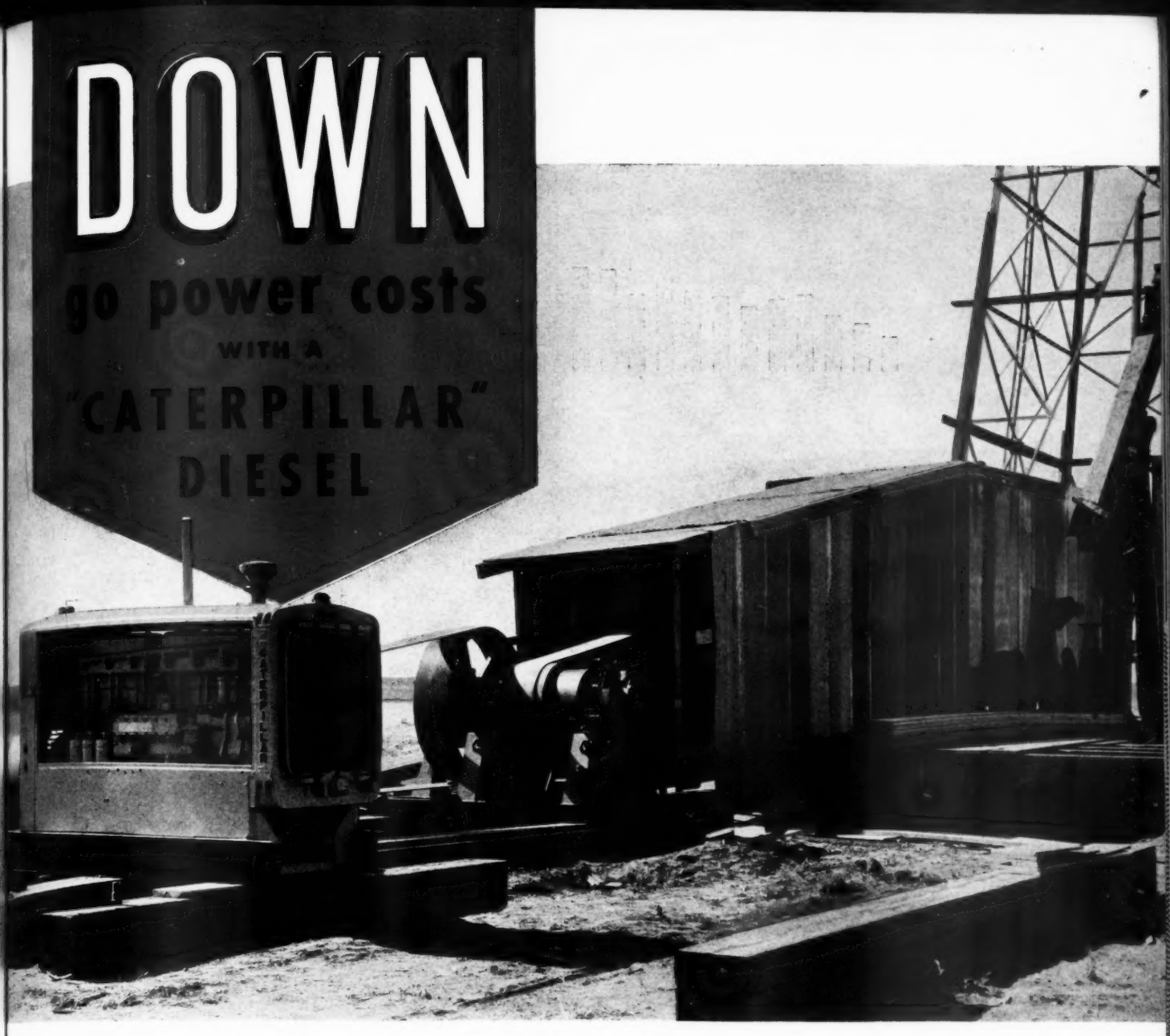
AVERAGE CRUDE PRICES

California	
Kettleman Hills	$1.22-1.43
Playa Del Rey	1.10
Coalinga	.70-.90
Signal Hill	1.10
Montana	1.35
Wyoming	.97-1.30
Colorado	1.12-1.18
New Mexico	.78-1.08
Texas	
North Central	.96-1.20
Panhandle	.91-1.08
West Texas	.78-1.08
Gulf Coast	.95-1.41
Darst Creek	1.09
East Texas	1.27
Talco	.73
Kansas	.98-1.30
Oklahoma	.98-1.30
Arkansas	.90
Louisiana	
Rodessa	$ .93-1.25
Gulf Coast	.84-1.41
North Louisiana	.90-1.22
Illinois	1.35
Kentucky	1.40
Indiana	1.12
Ohio	
Lima	1.25
Michigan	1.42
Pennsylvania	
Bradford	2.57
Southwest	2.32
Eureka	2.27
Buckeye	2.27
Corning	1.32
West Virginia	1.67
Canada	2.10 2.17

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.

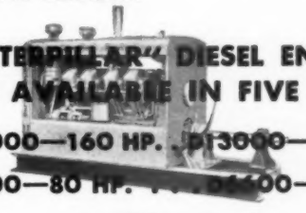
(Figures in Barrels)

	B. of M. Dept. of Int. Calculations (January)	Week Ended Jan. 30, 1937	Week Ended Jan. 2, 1937	Week Ended Feb. 1, 1936
Oklahoma	573,100	587,750	579,900	497,250
Kansas	165,600	173,600	165,850	137,200
Panhandle Texas		74,800	67,450	59,650
North Texas		65,600	63,650	56,550
West Central Texas		32,700	32,900	25,350
West Texas		171,200	167,350	147,900
East Central Texas		105,950	95,550	44,250
East Texas		449,350	447,100	433,300
Southwest Texas		187,550	178,850	117,250
Coastal Texas		180,950	170,500	157,200
TOTAL TEXAS	1,176,000	1,268,100	1,224,350	1,041,450
North Louisiana		86,350	80,850	57,350
Coastal Louisiana		165,150	161,350	131,300
TOTAL LOUISIANA	216,300	251,500	242,200	188,650
Arkansas	27,300	23,050	28,350	30,200
Eastern	112,200	116,000	119,350	96,300
Michigan	29,200	29,000	27,600	40,200
Wyoming	40,100	48,800	44,400	33,750
Montana	14,400	16,450	17,250	13,750
Colorado	4,500	3,550	3,650	3,900
New Mexico	79,800	92,850	86,200	58,000
TOTAL EAST OF CALIF.	2,438,500	2,610,650	2,539,100	2,140,650
California	559,900	583,400	582,300	674,900
TOTAL U. S.	2,998,400	3,194,050	3,121,400	2,815,550



ONLY in details do the stories of savings, efficiency and husky dependability differ among users of "Caterpillar" Diesel Engines. Here is a "Caterpillar" Diesel installation on a standard cable tool rig in the Russell, Kansas, oil field. Using low-cost fuel and constructed for long life and low up-keep, "Caterpillar" Diesels produce the kind of power that is demanded by oil operators. For drilling, pumping, generating electricity, or other requirements—they stand up to those demands. There's a dealer near you—with factory-trained service men and stocks of machines and parts.

This 125-hp. "Caterpillar" Diesel Engine is belt-connected to a standard cable tool rig. Telegraph control by means of a 24" bar mounted on control cross-shaft with two cables to well flow.



"CATERPILLAR" DIESEL ENGINES ARE AVAILABLE IN FIVE SIZES:

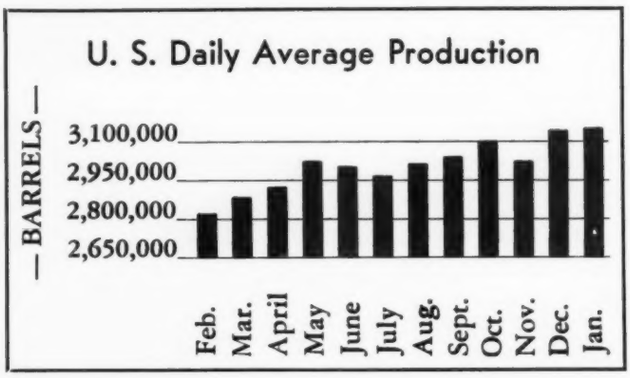
D17000—160 HP. D13000—125 HP.
D8800—80 HP. D6600—60 HP.
D4400—44 HP.

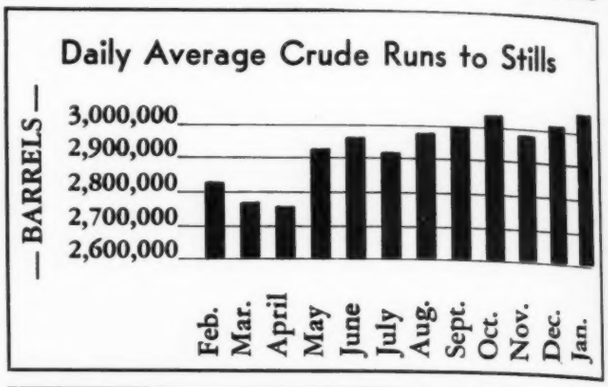
CATERPILLAR DIESEL ENGINES

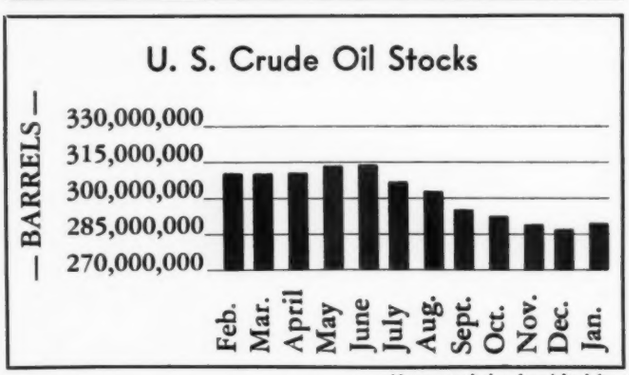
REG. U. S. PAT. OFF.

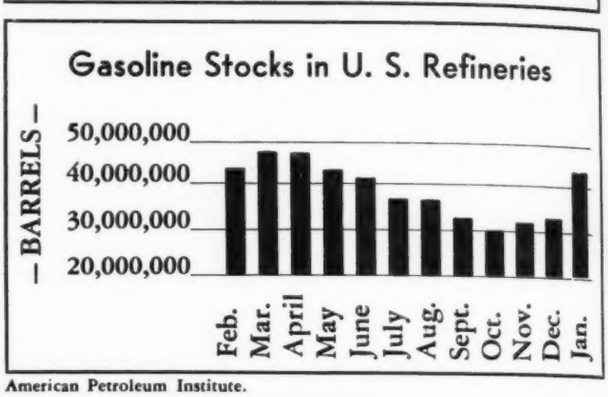
CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS
WORLD'S LARGEST MANUFACTURER OF DIESEL ENGINES

Summary of Petroleum Statistics and Field Activities









Above statistics furnished by the American Petroleum Institute.

Summarized Operations in Active Fields for January, 1937

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	160	151	37	47	3500-3700	2	40	Rotary
Duval County	61	51	22	49	1554-2900	2	22	Rotary
Archer County	34	13	2	14	660-1800	1 or 2	40	Rot.-Cab.
Panhandle	43	39	17	97	1700-3900	2	40	Rotary
Refugio	11	9	3	10	4900-5900	2	38	Rotary
Nueces County	49	44	15	49	3922-5878	2 or 3	21-54	Rotary
San Patricio County	8	6	2	8	3987-6141	2	23-65	Rotary
Talco Field	27	26	9	14	4230-4361	2	16-24	Rotary
Oklahoma								
Oklahoma City	12	12	3	26	6450-6682	3	39	Rotary
Fitts Pool	41	39	10	69	1800-4488	2 or 3	38	Rotary
Osage County	20	16	4	21	380-2850	2	37.5-40	Rot.-Cab.
Kansas								
McPherson County	10	9	2	12	2900-4300	2	38	Rot.-Cab.
Russell County	17	16	7	39	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	32	29	6	33	3222-4085	2 and 5	42-48	Rot.-Cab.
Reno County	11	7	5	15	3300-4375	2 and 5	42-48	Rot.-Cab.
Louisiana-Texas								
Rodessa	31	30	6	65	5950-6450	3	39	Rotary
New Mexico								
Lea County	47	43	4	84	3150-4030	.....	.....	Rotary
California								
Kettleman Hills	5	5	2	15	8300-8730	3 or 4	40	Rotary
Midway-Sunset	13	13	9	23	1400-3100	1 and 2	11-30	Rot.-Cab.
Mountain View	5	3	2	8	5200-6000	2	20-40	Rotary

Field Activities by States for January, 1937

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1936 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	.....	7	.....	4	.....	11	6	10	24	39	10,461,000
California	82	81	67	67	166	107	74	94	228	249	214,883,000
Colorado	1	2	0	0	.....	.....	2	3	22	29	1,670,000
Illinois	.....	11	.....	4	.....	.....	29	31	8	9	4,452,000
Indiana	16	.....	7	.....	.....	.....	6	4	24	26	795,000
Kansas	110	215	84	161	114	219	47	49	342	341	58,226,000
Kentucky	35	24	20	12	.....	.....	18	17	44	42	5,653,000
Louisiana	38	92	27	59	84	72	30	24	207	165	79,980,000
Michigan	57	76	29	41	74	59	74	68	140	128	11,852,000
Mississippi	.....	.....	.....	.....	.....	.....	2	3	8	10	Gas Prod.
Montana	10	17	9	16	.....	.....	2	3	44	52	5,632,000
New Mexico	48	58	43	57	.....	.....	15	17	119	121	27,134,000
New York	.....	.....	.....	.....	.....	.....	2	1	8	5	4,637,000
Ohio	172	161	135	125	.....	.....	83	81	264	236	3,834,000
Oklahoma	174	287	128	219	153	288	59	61	451	465	206,082,000
Pennsylvania	7	.....	5	.....	.....	.....	34	36	139	149	15,830,000
Texas	947	1225	716	958	1352	1185	551	451	1696	1396	391,097,000
West Virginia	68	32	53	30	.....	.....	31	44	171	193	3,903,000
Wyoming	7	20	7	13	.....	.....	4	4	46	54	13,650,000
Total	1772	2308	1330	1766	1943	1941	1069	1466	3985	3709	993,942,000

Faced with expiring leases, Mel E. Baish, President of the Maljamar Oil and Gas Company, accompanied by M. W. McNutt, geologist, sought to stake a location. His car stuck, Baish sighted an old Prairie Schooner wheel. Baish settled the question by saying, "Here we will drill Baish No. 1." It became the discovery well of Lea County, New Mexico, and led to such great developments as the Hobbs, Jal and Eunice fields.

Ability to act decisively is the mark of leadership. When drifted sand prevented securing surface geology, Mel E. Baish's decision to drill a site based on his own belief, protected his company's leases and opened the discovery well of Lea County, New Mexico. From the first, Dowell has shown similar leadership in its decisive development of well-treating methods and materials and the strength of its personnel.

DOWELL PARAFFIN SOLVENT

Highly successful among Dowell well-treating materials is Dowell Paraffin Solvent. This product removes paraffin from formation and equipment quickly and economically. It reduces shut-down losses, pulling costs, requires no heat thus eliminating expansion strains on pipe, leaves no melted paraffin to coat face of pay and is harmless to equipment and formation. Write for further details or ask any Dowell representative.

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DOWELL INCORPORATED · *Subsidiary of* THE DOW CHEMICAL COMPANY · *Executive Office:* MIDLAND, MICHIGAN · *General Office:* KENNEDY BUILDING, TULSA, OKLAHOMA
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OIL AND GAS WELL CHEMICAL SERVICE

The Month's Activities In Refining

Percent Refinery Capacity Operated

Western Division, 65.2 Percent **Central Division, 72.1 Percent** **Eastern Division, 81.0 Percent**

CONSTANTIN AND COMPANY have almost completed their new $150,000 refinery one and a half miles southeast of Talco, Texas. The plant should be in operation some time in February, according to Charles Constantin, in charge of operations.

The plant's equipment will include a cracking unit, treating plant, storage tanks, etc. A 10-car loading rack has been completed on the refinery property, and new offices have been constructed. The American Liberty Oil Company will supply the Constantin plant with crude.

A unit for the manufacture of asphalt soon will be added to the refinery's equipment, Charles Constantin states.

●

The Bradford Oil Refining Company, Bradford, Pennsylvania, plans the erection of a cracking and reforming unit, a solvent dewaxing plant, and additions to its boiler and filter house.

●

The Northern Natural Gas Company, with headquarters in Omaha, Nebraska, has announced they will construct a sour gas treating plant in Rush County, Kansas, the plant having a capacity of 40,000,000 cu. ft. of gas daily. The company also will add a second contactor at its gas dehydration plant near Skellytown, Texas. As a result of the addition of this contactor all plants of the company will be equipped for the dehydration of gas entering its pipe lines from Texas and the Hugoton, Kansas, areas. Also as a part of its 1937 construction program a 300-hp. boiler is to be installed at its gasoline plant near Hugoton.

●

The Atlantic Refining Company has begun construction of a thermal polymerization plant at its Philadelphia refinery, to cost $2,300,000. The plant will manufacture gasoline from the gas generated during the cracking stage of the refining process, and will have a daily capacity of 62,500 gallons.

A 5500-bbl. cracking plant has been announced for Trenton, Michigan, by the Dixie Refining Company. Contract has been awarded to Arthur G. McKee and Company, Cleveland, Ohio. The plant will operate a Dubbs unit under license with the Universal Oil Products Company. The refinery will be connected with a water terminal on the Detroit River. The plant is expected to be completed the latter part of the year.

●

Aetna Oil Service, Inc., who operate a refinery at Louisville, Kentucky, have taken a license under patents of Gasoline Products Company, Inc., for their cracking operations. Cracking facilities at the Aetna refinery currently employ a type of two-coil operation for the cracking of residual feed stocks.

●

The absorption-type natural gasoline plant being constructed in the Saxet field of Texas by the Southern Minerals Corporation is now well underway. The Western Supply Company of Tulsa, Oklahoma, is in charge of the construction work. The plant's capacity will be from 25,000,000 to 30,000,000 cu. ft. of gas daily.

●

Petrol Block, S.A.R., has obtained a license from The Gray Process Corporation for clay-treating the cracked gasoline to be produced from a Dubbs unit at its refinery "Standard" at Ploesti, Roumania. The installation will have two Gray towers operated in series. It will treat gasoline produced from a combined coking and flashing operation on topped Roumanian crude charging stock.

●

The Chartiers Oil Company, Pittsburgh, Pennsylvania, has awarded a contract for the construction of a natural gas purification plant at Wayne, West Virginia, to Koppers Company's Engineering and Construction Division.

The plant will employ the new Koppers sodium phenolate process, and will recover 95 percent of the hydrogen sulphide in the gas. It will have a capacity of 5,000,000 cu. ft. daily.

Construction will begin in June, and the plant will be ready for operation by September.

Crude Runs to Stills, Gasoline, and Gas and Fuel Oil Stocks
Week Ended January 30, 1937
A.P.I. Figures
(Figures in Barrels of 42 Gal. Each)

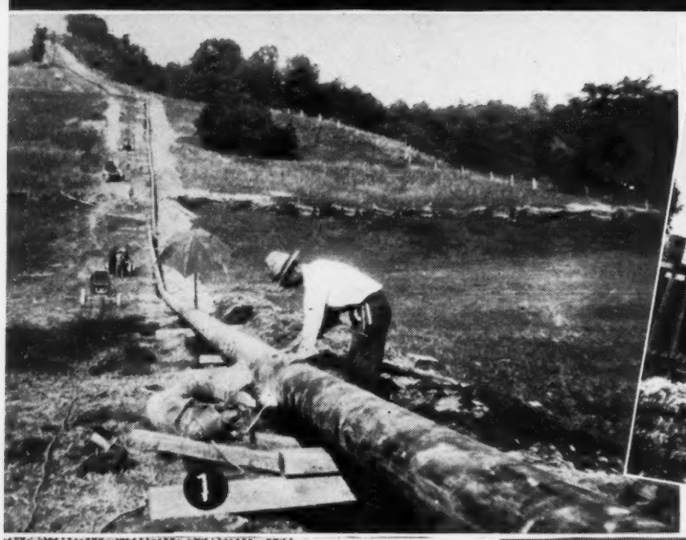
DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	517,000	77.3	14,543	8,479
Appalachian	88.4	103,000	79.8	2,546	616
Ind., Ill., Ky.	89.5	391,000	86.1	11,055	5,102
Okla., Kans., Mo.	84.6	290,000	76.3	7,647	2,939
Inland Texas	54.3	99,000	54.1	1,956	1,430
Texas Gulf	95.5	682,000	90.1	9,854	6,901
La. Gulf	96.3	140,000	88.6	1,648	1,836
No. La.-Ark.	63.7	30,000	51.7	360	473
Rocky Mt.	69.7	42,000	67.7	1,402	709
California	90.9	468,000	62.7	13,723	71,099
Reported	88.4	2,762,000	76.8	64,734	99,584
Est'd Unreported		233,000		4,806	2,494
*EST'D TOTAL U. S. Jan. 30, '37		2,995,000		69,540	102,078
*EST'D TOTAL U. S. Jan. 23, '37		3,055,000		68,180	103,441
U. S. B. of M. *Jan. 30, '36		**2,767,000		62,558	100,613

*Estimated Bureau of Mines basis.
**January, 1936, daily average.

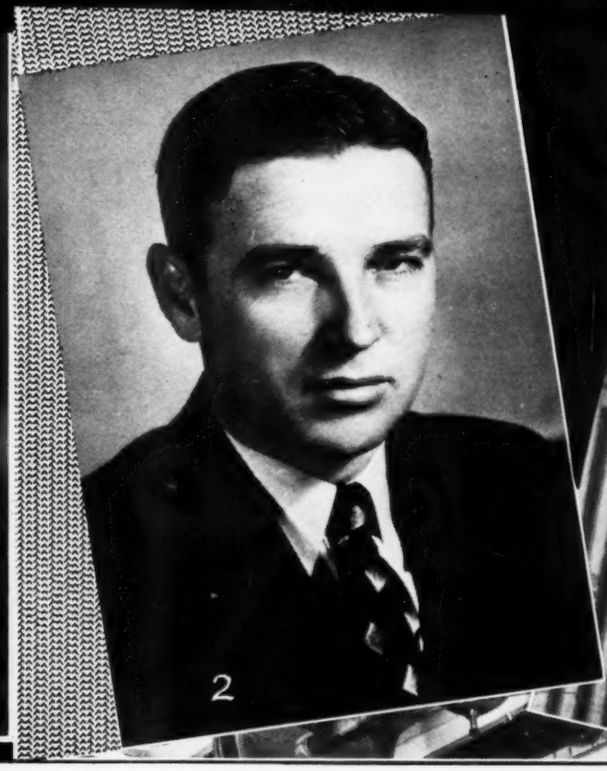
Pictorial PETROLEUM

Preparing to Cement a Well on the Gulf Coast

A REGULAR FEATURE OF THE PETROLEUM ENGINEER

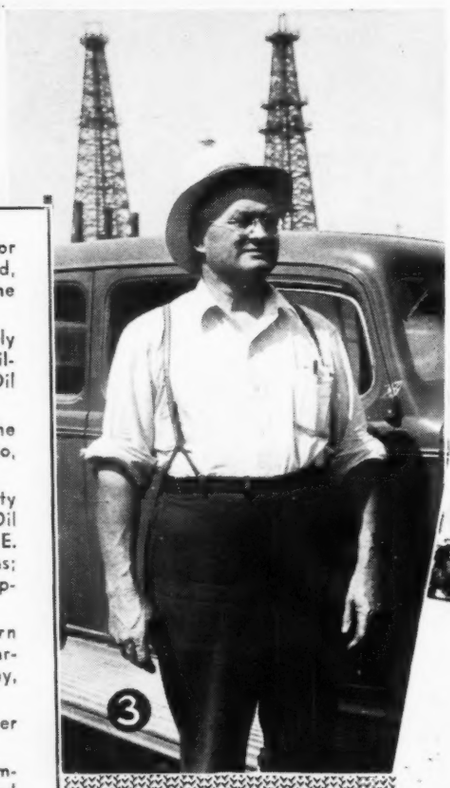


1. Electric welding on Hope Natural Gas Company's 12-in. line from Clendenin to Hastings, West Virginia.
2. Portable rotary oil drilling outfit in operation in 1899 in what is now residential section of Los Angeles. Note small rotary table, crude drawworks and 1½-in. rotary hose.
3. Frank Markle, Jr., petroleum engineer for the Gulf Production Company, Houston, Texas.
4. Rising out of the Arizona desert this monument perpetuates the name of the man who drove the only camel caravan ever to trek this land. In Arabic the man's name was Hadji Ali but in the lingo of the American soldier he was just "Hi Jolly." Lettering on the epitaph was accomplished with an electric arc. Photograph courtesy Lincoln Electric Company.
5. Magnolia Petroleum Company's gasoline plant in the Sayre pool near Kermit, Texas, capacity approximately sixty million feet daily.

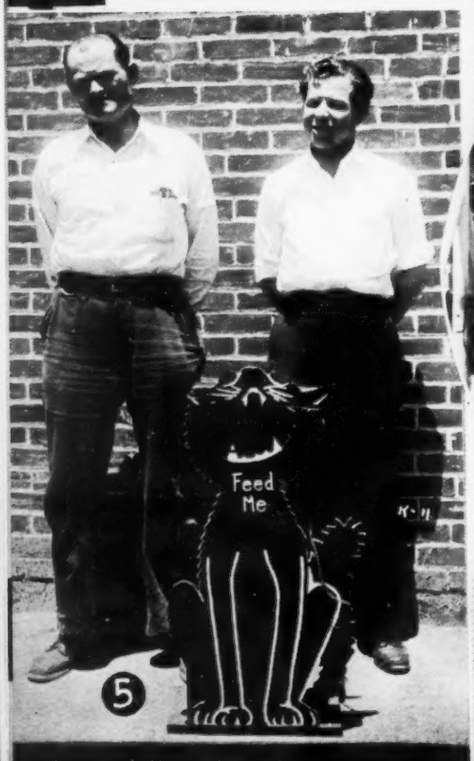


1. C. A. Cromwell, process engineer for Salvex Refineries, Inc., Gladewater, Texas. He was formerly associated with Corpus Christi Refining Corporation, at Corpus Christi.
2. Roy Blackbird, Southwest manager for Crane Packing Company, Houston, Texas.
3. P. L. Talley (left), Hughes Tool Company, Rodessa, Louisiana, and W. A. Weir, store manager for Oil Well Supply Company at Rodessa.
4. Wives, children and relatives of the employees of The S. M. Jones Company, Toledo, Ohio, manufacturers of sucker rods, were invited to the plant during the holidays for an entertainment provided by company officials. Highlights of the visit included a side-by-side operation of the first sucker rod normalizing furnace installed in 1928 with the new normalizing furnace which has three times the capacity of the original, running 200 rods an hour. The guests were also conducted through the laboratory, the engineering, the die-making, and couple-making departments. Refreshments followed and a short historical account of the organization was given by President P. C. Jones. The S. M. Jones Company old-age, sickness, life insurance and retirement policy, which has been in effect 30 years, was also discussed. Seventeen employees who have been with the company for 25 to 42 years were introduced.
5. Group photograph of the 131 Oil Center Tool Company employees at a get-together party during the holidays. Ten years ago this company had six employees.

California and Texas Operating Men



1. W. A. Chaney (left), district manager for International Supply Company at Midland, Texas, and John L. Rice, representative for the Walworth Company, Odessa, Texas.
2. Stanley Coppinger (left), Continental Supply Company, Hobbs, New Mexico, and I. L. Dillard, drilling superintendent for C. & G. Oil Company, Dallas, Texas.
3. G. C. Sproule, general superintendent for the St. Helens Petroleum Company, Montebello, California.
4. Left to right—J. F. Johnson, Marolin Casualty Company, El Paso, Texas; Walter Burke, Oil Center Tool Company, Odessa, Texas; A. E. Warner, The Texas Company, Wink, Texas; Henry F. Oliver, store manager for Atlas Supply Company, Kermit, Texas.
5. J. H. Lasius (left), superintendent, Southern California Drilling Company, and H. H. Harmon, store manager, National Supply Company, both at Huntington Beach.
6. Alexander Anderson, president of Alexander Anderson, Inc., Fullerton, California.
7. Left to right—M. F. Wilson, The Texas Company; J. H. Annand, The Texas Company; and Joe Shell, representative for Petroleum Equipment Company, all at Montebello, California.



All DEPARTMENTS* BENEFIT FROM PETRECO ELECTROMATIC DEHYDRATION

The various departments of an oil company may view the dehydration of "cut" oil from different angles, since the water in crude affects each one in a different way. One factor common to all departments, however, is the increased cost of handling emulsified crude as compared to the cost of handling thoroughly dehydrated oils.

While the increased handling cost to either the production, transportation or refining department may not appear to be of critical proportions when considered individually, it must be borne in mind that this increase is cumulative from the time the oil is produced until it is manufactured into refined products. Conversely, the advantages of Petreco Electromatic Dehydration, also being cumulative, accrue to all departments involved.

It is from this standpoint that those charged with dehydration procedure should view the problem. For, even though it may not prove as profitable to one department as to another, it is nevertheless true that Petreco Electromatic Dehydration of ALL "cut" production will pay dividends to all departments from the well through the refinery.

***PRODUCTION**
- Lowest Cut
- Highest Gravity
- Less Tank Cleaning
- Less Tank Corrosion
- Less Tank Bottom Disposal
- Increased Storage Capacity

***TRANSPORTATION**

(PIPE LINE)
- Lower Viscosity
- Lower Pressure
- Higher Line Capacity
- Lower Pumping Costs
- Lower Pipe Line Maintenance
- Less Corrosion
- Less Tank Bottom Disposal
- Increased Tank Storage

(MARINE)
- Lower Shipping Costs
- Increased Tanker Capacity
- Less Tank Bottoms

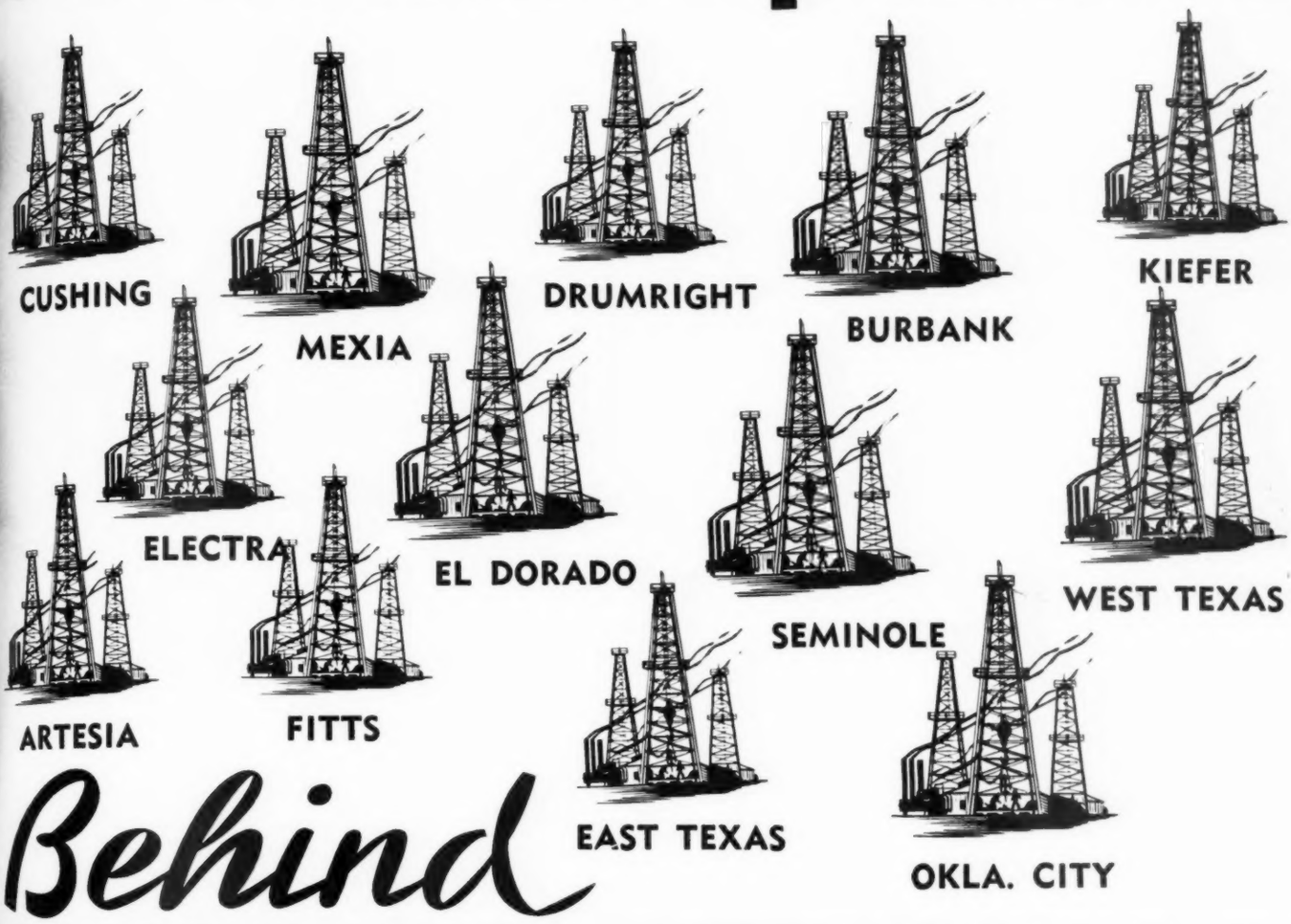
***REFINING**
- Purer Residual Products
- Less Corrosion
- Increased Still Capacity
- Lower Fuel Costs

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA

General Offices: 530 West Sixth Street, Los Angeles, California. Branch Office, Houston, Texas. Branches and Service Men in Principal Oil Fields.

1. Left to right—O. L. Grosz, store manager; J. L. Jean, warehouseman; Louise Rogers, stenographer; F. C. Ritterbush, clerk, and R. E. Williams, salesman, all with Continental Supply Company at Casper, Wyoming.
2. Walter Swaney, prominent valve manufacturer, getting an early start to the 1937 A.P.I. convention.
3. Carter C. Miers, who recently joined the Delta Drilling Company as production superintendent in the East Texas field, with headquarters at Longview. Other officers of this company are Joe Zeppa, president, R. A. Stacey, vice president, and Claude Johnson, general superintendent.
4. Showing the process area of the Glenrose Gasoline Company's plant in the Rodessa field. This plant, in addition to the manufacture of natural gasoline, is equipped for stabilizing crude oil, in the manner of the one constructed by the Continental Oil Company in the Tepetate field of South Louisiana. The crude stabilizer is shown in the accompanying photograph, the fourth unit from the left.
5. Interlude on the ferry, interrupting a Sunday "joy ride" in the Maxwell side-winder, 1905 vintage, in Leamington, Ontario, Canada. The young man on the left of the driver is Harold "Baldy" Blythe, now shop superintendent for Martin-Decker Corporation.
6. J. D. Weedon (left), superintendent, El Te Jon Refinery, Bakersfield, California, and W. J. Jans, production clerk with Wood-Callahan Company, at Bakersfield.

30 Years Experience



Behind INTERNATIONAL Supply Stores

Thirty years ago, when Oklahoma was still the Indian Territory and before the production, transportation, refining and marketing of petroleum became a major world industry, and when the Mid Continent field was a matter of future development, this organization was pioneering the manufacture of oil field equipment.

Through the years it has faithfully served the needs of operators in the boom days of Cushing, Mexia, Drumright, Burbank, Electra, El Dorado, Garber, Artesia, Seminole, Hobbs, Oklahoma City, East Texas and Fitts. We have won our spurs through long years of faithful service; earned the privilege of serving a great industry.

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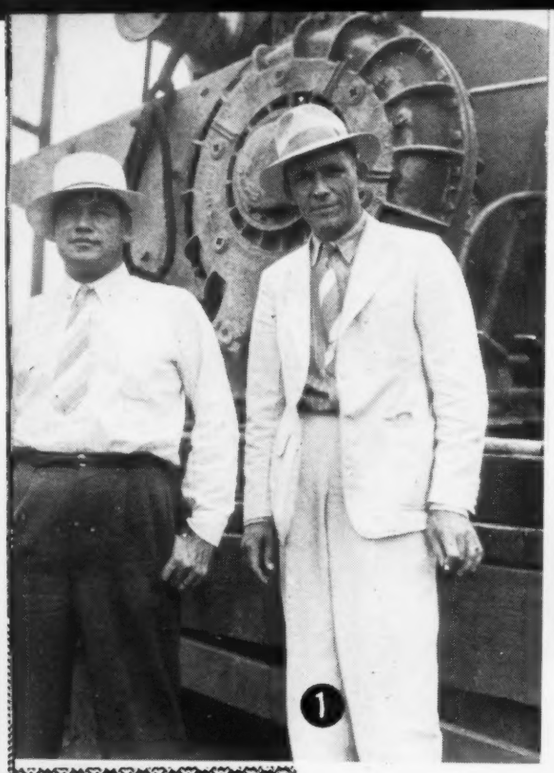
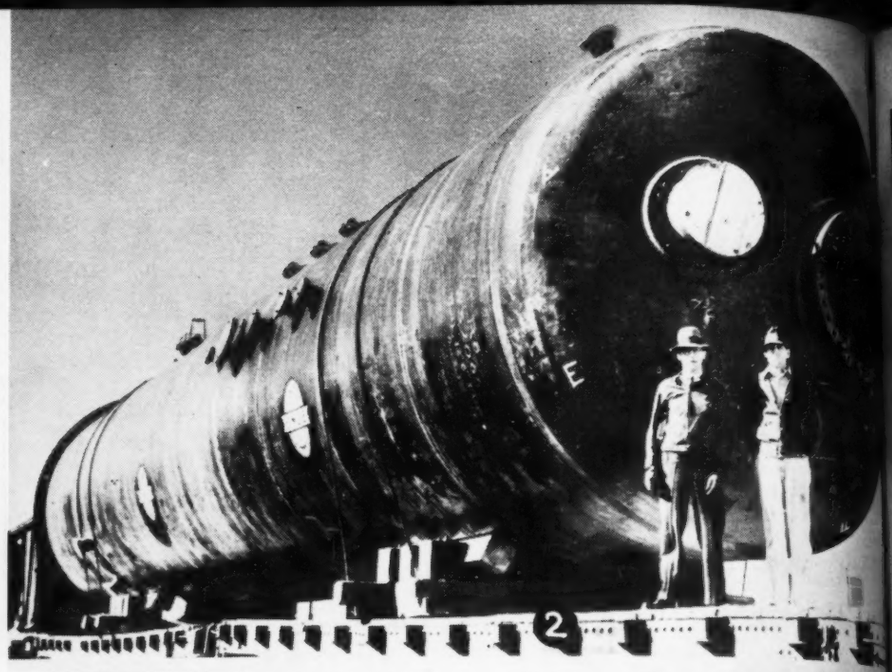
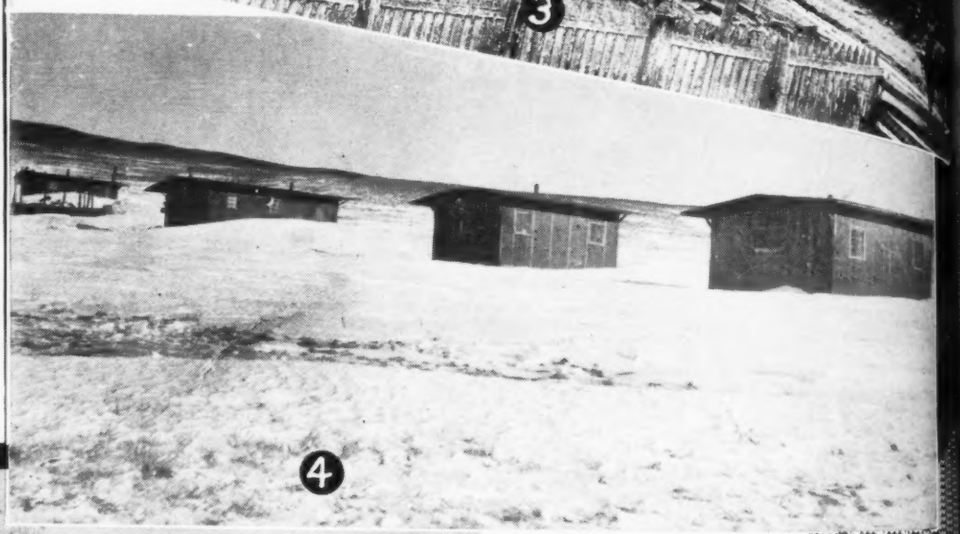
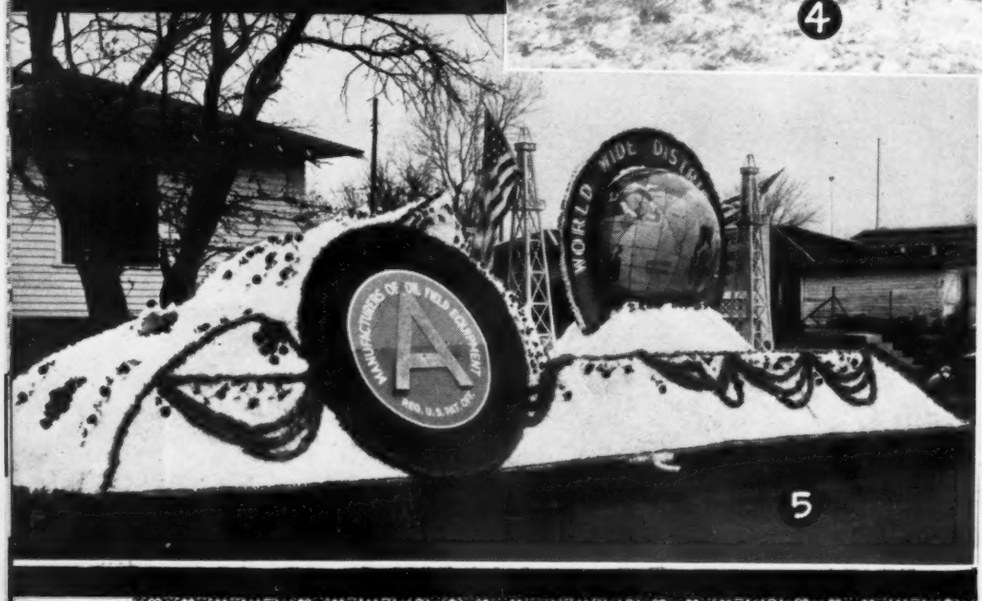




1. E. F. Richards (left), and T. M. Rowan, owners of Kearn Drilling Company, Bakersfield, California.
2. Photograph of the largest tower ever built and shipped by Black, Sivalls & Bryson, Inc., Oklahoma City. It was engineered by Universal Oil Products Co., Chicago, for erection at Big Spring, Texas, plant of Cosden Oil Corporation. The tower is 12 ft. 6 in. in diameter, 80 ft. 3 in. overall length and weighs 108 tons——216,000 pounds.
3. Transportation difficulties of thirty years ago. Hauling bedplate for compression station of Hope Natural Gas Company in central West Virginia.
4. Typical but not tropical wildcat camp of Midwest Oil Company, Ringling, Montana.
5. Attractive float of the American Iron & Machine Works Company at the meeting of the Independent Petroleum Association.
6. Left to right—C. W. Morris, store manager of National Supply Company, Casper, Wyoming; D. A. Sikes, Mid-Continent manager (Tulsa) for Baroid Sales Company; and J. W. Gillespie, district manager for National Supply Company at Casper, Wyoming.





His Strongest Quality was—

FORTITUDE

Says Woodward, biographer of Washington:*

"His strongest quality was fortitude. The fighter who stays in the ring as long as he can stand on his feet. . . . the captain who clings to his ship while there is a plank left afloat—that is Washington."

In man, Fortitude—in pumps, DURABILITY! The ability to "stand the gaff"—to plod along endlessly! Gaso Pumps are famous for this quality. It is based in their simple and rugged design—few large parts exceptionally well made from finest materials—in their even distribution of the weight of moving parts—in their Timken Roller Bearings. Many Gaso Pumps built twenty years ago are still in use . . . Gaso Pump & Burner Mfg. Co., Tulsa, Okla. Export Office: 149 Broadway, New York.

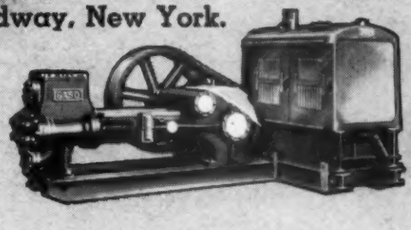


Fig. 1740 Gaso Duplex Piston Timken Bearing Power Pump 54 to 250 Bbls.

Complete Gaso Condensed Catalog, in 1937 Composite Catalog

GASO PUMPS
for every oil industry need

*From "George Washington, the Image and the Man."—Liveright Publishing Corp.

Above—H. L. Patton, renowned oil well fire fighter, Houston, Texas, and some of the jobs he has performed.

1. South West Drilling Company's wildcat well in McMullen County, Texas.
2. Dixon Royalty Company well at Clarkwood, Texas, on which the men are working under heavy two-inch lumber for protection.
3. Fire cutting the derrick on a well at Clarkwood, Texas.
4. Manifold stabbed on a well of Texon Royalty Company in Plymouth Field at Taft, Texas. This operation enabled the crew to close the valve.

Below — Mission Manufacturing Company salesmen from the Mid-Continent and California areas attended the semi-annual sales meeting held at the company's main plant at Houston, Texas, early in January.

Following a trip through the plant to observe Mission's modern shop practices, intensive studies were made of each individual product and the specific benefits advanced design and careful manufacture and inspection gives the user. The meeting was followed by a banquet at the Houston Club. The above photograph of Mission sales officials and salesmen was taken at the close of the sales meeting.

WILLIAMSPORT

PURPLE STRAND Form-Set

Some fellow once said, "You get what you pay for." A good phrase but not always true except when buying Williamsport Wire Lines.

The Telfax System of grade marking, exclusive with Williamsport, has been a "Godsend" to users who have heretofore had extreme difficulty in checking the quality of steel used in various grades of lines of other make.

To those whose operations can use *Pre-formed* Wire Lines we offer our Purple Strand "Form-Set" with full confidence that the extra service it will render makes its use one of great merit and outstanding economy.

WILLIAMSPORT WIRE ROPE CO.

Williamsport, Pennsylvania — **122 South Michigan Avenue, Chicago, Illinois**

OTHER OFFICES IN ALL PRINCIPAL CITIES

Oil Country Sales Offices: Williamsport Bldg., Fourth and Midland Valley Tracks, Tulsa, Oklahoma; 10 North Milby Street, Houston, Texas

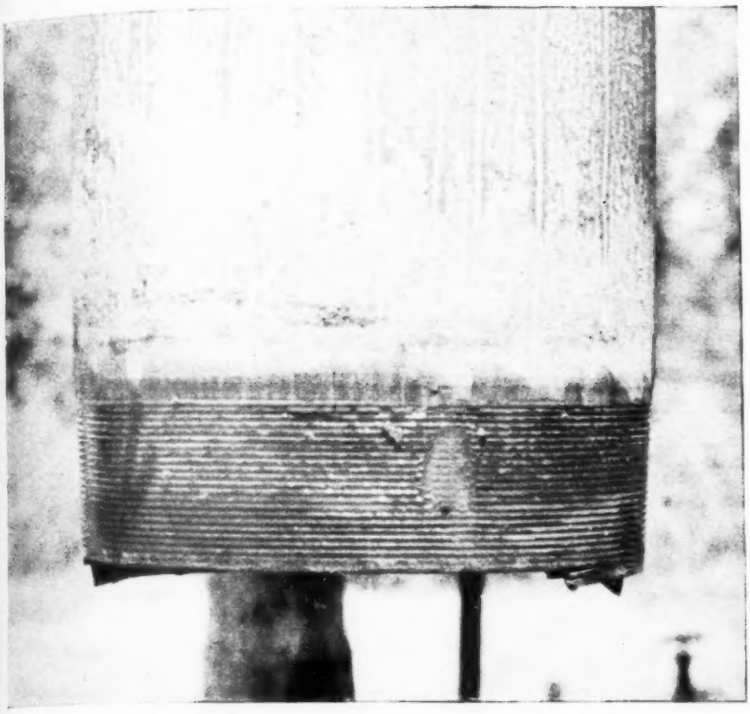
Distributors in Texas, Louisiana and Arkansas: Mid-Continent Supply Company.
General Machine and Tool Company, Distributors in Kansas.
American Pipe and Supply Company, Distributors in the Rocky Mountain Territory.

The three photographs grouped at the top of this page were taken at the barbecue sponsored by Black, Sivalls & Bryson, Inc., during the I.P.A. meeting in Oklahoma City. Left—Bruce Lerch of Phillips Petroleum Company; Above — A group of the more than one thousand oil men who attended; and, Right—Jim Stevens of Phillips Petroleum Company.

4. Taken in the Oklahoma City field, the photograph shows J. C. (Shorty) Dinger, Magnolia Petroleum Company; Joe Cannon, Reed Roller Bit Company; and J. W. (Skeet) O'Melveny, Patterson-Ballagh Corporation.

5. Left to right: W. W. Squyers, engineer; J. C. Montgomery, production department; and V. M. Pratt, production superintendent, Phillips Petroleum Company. The photograph was taken at Hobbs, New Mexico.

6. Section of the new five million dollar refinery being built near Port Arthur, Texas, for the Atlantic Refining Company. At the left are shown the two cracking furnaces with 200-ft. stacks. At the right is the main tower group of the cracking unit. The M. W. Kellogg Company is building the plant.



Threads Damaged by Improper Casing Protection

Prevent

whipped casing and torn threads this simple way

Install

PATTERSON-BALLAGH

DRILL PIPE STABILIZERS

The above unretouched photograph shows a 12½" casing used in the Rodessa field which broke at 400'. It required one week's fishing time plus an expensive recementing job. The damage was caused primarily by whipped casing. This could have been prevented by the use of Patterson-Ballagh Drill Pipe Stabilizers.

These Stabilizers keep the drill pipe centered, and form a resilient rubber cushion which softens the contact against the casing. The cost of Stabilizers will be repaid to the operator many times.

Ask for descriptive literature and complete specifications.

●

PATTERSON-BALLAGH CORPORATION

Plant and General Offices: 1900 East 65th St., Los Angeles, Calif., U. S. A. *New York Office:* 39 Cortlandt St. *Oklahoma Office:* Oklahoma City, 1704 N. W. 17th St. *Texas Office:* Houston, 515 M & M Building. *Louisiana Office:* Box 23, Oil City, La.

ALL-RUBBER PROTECTION FOR YOUR WELL . . .

Patterson-Ballagh Drill Pipe Stabilizers have an extra large diameter. The O.D. ranges from 7" to 19½". If used in stove-pipe casing these Stabilizers will practically eliminate trouble from collapsing or from a broken seat. Complete protection is given to the threads. Casing will not wear thin and cause water leaks.

1. E. D. Smith, production manager of Magnolia Petroleum Company, Oklahoma City.

2. C. S. (Doc) Cook, Noble Drilling Company, Oklahoma City.

3. Taken in Cass County, Texas, this photograph shows (left to right): Bill Williams, "Dutch" Lane and Milt Burgin, all with United Gas Company.

4. H. P. Boncher, new sales manager of S. R. Dresser Manufacturing Co., Bradford, Pa.

5. R. E. Reimer, who recently assumed the duties of treasurer and assistant general manager of S. R. Dresser Manufacturing Co., Bradford, Pa.

6. Photograph taken at the annual sales meeting of the Midwest Equitable Meter Company-Merco Nordstrom Valve Company at Tulse, Okla. The sales territory for this district, in charge of A. J. Kerr, includes Oklahoma, Arkansas, Texas, Louisiana and New Mexico. Colonel W. F. Rockwell of Pittsburgh, president of the parent companies, attended the meeting, as did the following salesmen: M. D. Gilbert, C. K. Madison, E. P. Martin and C. R. Parker, Houston; F. A. Arnesen and W. R. McLaughlin, Dallas; W. J. McArt, Oklahoma City; O. W. Barnett, Shreveport; R. R. Bush, J. H. Baker, J. L. Cottrell and F. N. Dillman, Tulsa.

THE Petroleum Engineer

FEBRUARY, 1937

Blending Gulf Coast Crude with Natural Gasoline for Foreign Shipment

Plant recently constructed at Corpus Christi, Texas, by Hanlon-Buchanan, Inc., embodies numerous interesting features

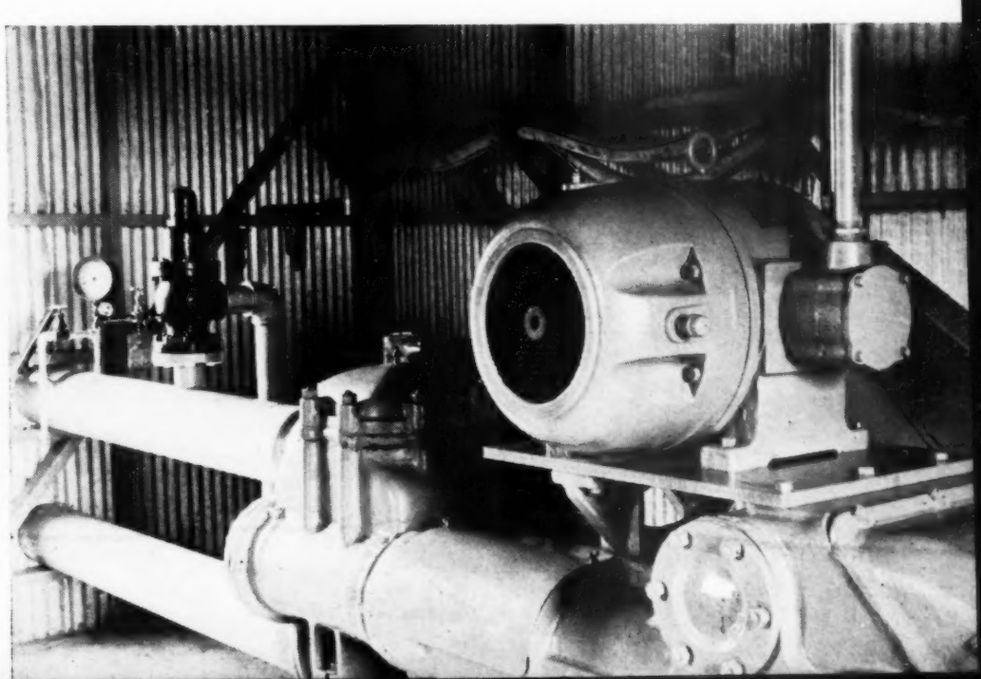
By

FRANK H. LOVE

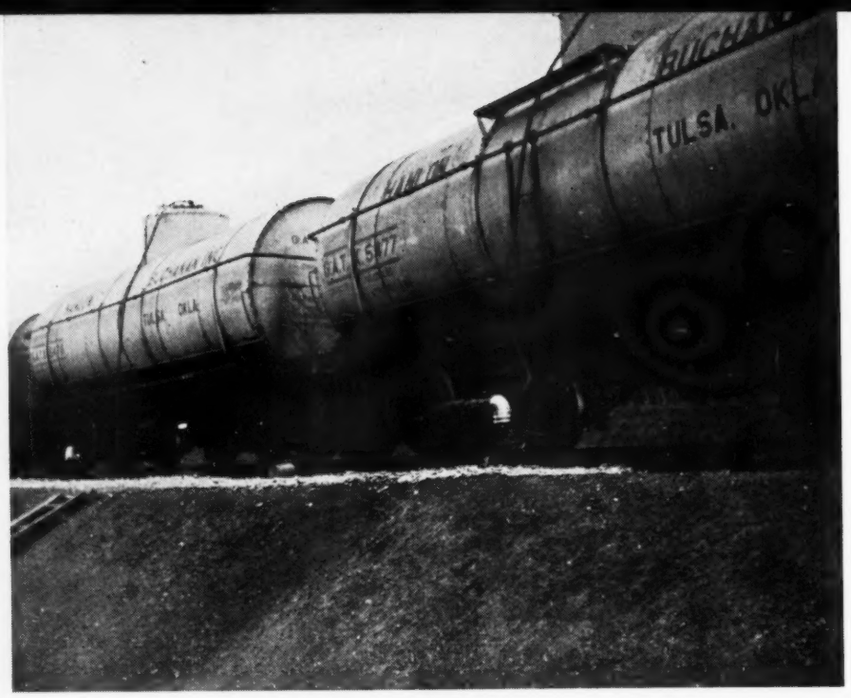
FOR blending natural gasoline with crude oil, raising its gravity to meet specification for shipment abroad, Hanlon-Buchanan, Inc., recently placed in operation at Corpus Christi, Texas, an efficient and completely modern plant. The crude oil is from fields in the vicinity of Corpus Christi, principally Saxet, and is of too heavy a gravity to meet the demands of French buyers, to which country it is being shipped at present. The blend is being made in proportions of six percent 22-lb. natural gasoline to 94 percent crude oil.

Natural gasoline is received in tank cars, for the most part from the Refugio and Sinton areas, although some comes from as far away as Breckenridge and the Texas Panhandle. The gasoline is from the plants of the Hanlon-Buchanan organization, as well as from those of other companies. The crude is transported to the blending plant by the Southern Pipe Line Corporation, whose dock also is being utilized for the loading of cargoes.

The blending method follows the accepted standard for best practice. When received at the plant the tank cars containing natural gasoline are spotted on a 10-car spur track inside the grounds. From the cars the gasoline is pumped into pressure storage tanks, the latter consisting of ten 10-ft. by 40-ft. horizontal tanks, each



This motor-driven reciprocating pump, employed for unloading tank cars and for boosting gasoline to the blending tanks, is specially equipped with a safety valve to prevent overloading



A constant pressure is maintained on both the tank car and pressure storage tank while unloading by means of the arrangement illustrated here. The hose shown entering the top of the car carries gas that is being displaced from the pressure storage tank as the natural gasoline enters

having a capacity of 24,000 gallons. A novel arrangement makes it possible to maintain a constant pressure on both tank car and pressure tank during unloading, accomplished by extending a vapor line from the pressure tank receiving the gasoline to the car from which it is being unloaded. In this manner, as the gasoline is removed from the tank car it is displaced with an equal volume of vapor that in turn is being displaced from the pressure tank by the gasoline. During unloading a constant pressure of 15 lb. is maintained on both the tank cars and the pressure storage tanks. Seven of the latter, incidentally, are of 60-lb. test, and three are of 125-lb. test. The three vessels of 125-lb. test eventually will be utilized for the storage of butane that at a later date is to be used in the blending process. Five of these tanks also are equipped with spreaders and can be used when needed for blending butane with casinghead gasoline before it in turn is blended with crude oil. Pressure is held on the tank cars only so long as they are being unloaded, and as soon as this is accomplished the vapor is vented to atmosphere. Gas for repressuring the storage tanks after the gasoline has been pumped from them into the blending tanks is obtained from the Corpus Christi Refinery, a few hundred feet distant from the Hanlon-Buchanan plant. It is taken from the refinery at a pressure of 80 lb., is passed through back-pressure regulators and reduced to a pressure of 15 lb. before entering the pressure storage.

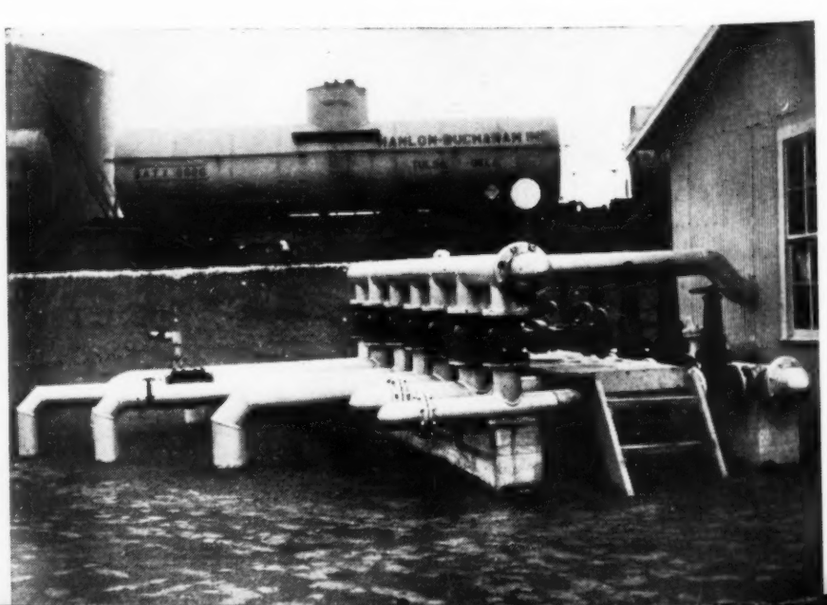
The crude oil and 22-lb. natural gasoline are blended in two 93,000-bbl., one 80,000-bbl., and one 20,000-bbl. tanks, the bottoms of which are provided with spreaders. As the natural gasoline is pumped into the bottom of the tanks it spreads upward through the crude oil, blending with it. The tanks now in use belong to the Southern Pipe Line Corporation, whose pumping station adjoins the blending plant. Hanlon-Buchanan, Inc., have erected a 93,000-bbl. tank that later will be utilized. This tank is connected to the terminal by an 8-in. line and is equipped with a water-spray system on top for cooling during hot weather.

For unloading tank cars into the pressure storage, and for boosting the gasoline to the blending tanks, an 8 by 10 reciprocating pump, motor-driven, is employed. This unit, set in a concrete foundation and housed in a steel frame, galvanized-covered, building, is specially equipped with a safety valve on the discharge line to prevent overloading of the pump. Set for 45 lb., the fluid is by-passed into the suction line when that pressure is exceeded. A manifold of the crossover type, situated immediately outside the building housing this pump, is so arranged that gasoline can be pumped from tank cars to any given storage tank, or from one storage tank to another as desired. All blending lines to crude tanks are 6-inch.

Loss from evaporation is minimized by following a policy of blending cargoes immediately before they are loaded. The capacity of the tanker, usually from 4200 to 7200 bbl., and the speed at which blending is possible (800 bbl. an hour) determine the time allowed for the preparation of a cargo before the ship docks. When ready for loading, the tanks containing the blended product are put on the line and the latter boosted to the loading terminal by two centrifugal pumps driven by 75-hp. motors. This equipment is capable of pumping 6500 bbl. an hour through a 14-in. line.

A complete laboratory is maintained at the plant for testing the casinghead gasoline upon arrival to assure its meeting specifications. The laboratory is equipped for making all tests of casinghead gasoline with the exception of determining the octane number, not required in this work.

Due to the inflammable nature of the products handled the plant is adequately provided with a foam system for fighting fires, a number of fire stations being spotted throughout the grounds..



The manifold is situated immediately outside the building that houses the pumping equipment shown at the top of this page

Making a tie-in on the 12-in. line near Concord, California

Modern Engineering Features Embodied In California's Newest Pipe Line System

Shell's system from Bakersfield to Martinez made elastic to provide for economical transportation of crude oils having a wide range of gravities

By F. B. SIMMS, Superintendent of Pipe Lines, Shell Oil Company

THE history of Shell pipe lines in the San Joaquin Valley began in 1914, when the company built a line to transport Coalinga crude to its new refinery at Martinez. This line was a pioneer in the method of transporting heavy, viscous crudes with the aid of heat.

After 22 years this line is still in operation with the original pipe, still using the same pumping equipment, and to a large extent, still the same auxiliary equipment.

For more than a decade following completion of the line Shell's attention was turned to other fields of production, most important of which was Signal Hill, which it discovered. It also had a big share in developing Santa Fe Springs, Brea, Dominguez, and Ventura Avenue fields. A network of pipe lines was constructed to tie these fields into the company's refinery at Wilmington.

In the San Joaquin Valley, Shell discovered the Mt. Poso field, acquired large holdings in the Round Mountain and Kettleman Hills fields, discovered Mountain View and developed the Edison field.

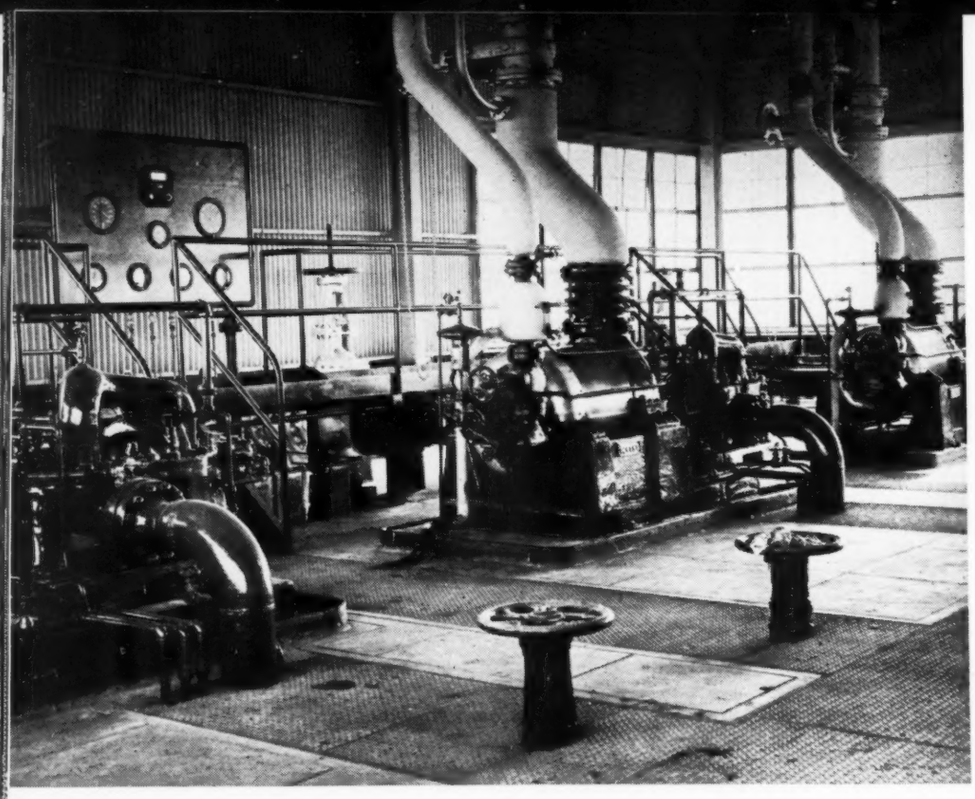
The company had no pipe line in this area at that time and the Coalinga-Martinez line was already taxed to capacity. When Ten Section field was discovered last year the need for an additional line became urgent. So Shell's new Bakersfield-Martinez pipe line, capable of meeting present and future requirements, including a central tank farm and a system of lateral lines, was laid and placed in operation.

This new trunk line is a complete and separate system designed to work in conjunction with the existing line laid in 1914 between Coalinga and the Martinez refinery. The new system required the construction of four pump stations between Bakersfield and Coalinga and mechanical additions to the six existing pump stations between Coalinga and Martinez.

Four lateral lines were constructed as a part of the project; an 8-in. line from the Mt. Poso field, 12.29 miles long; a 6-in. and 8-in. line, 9.28 miles long, from the Round Mountain field; an 8-in. line, 17.21 miles long, from Shell's newly-discovered Ten Section field; a 6-in. line, 20.6 miles long, from the Mountain View-Edison area. All terminate at a central tank farm.

The new main line from Bakersfield tank farm via Caliola pump station near Coalinga, to Martinez, is 257.98 miles long and consists of 189.54 miles of 10-in. pipe and 68.44 miles of 12-in. pipe.

The old, or existing line, from Caliola pump station and tank farm to Martinez refinery consists of 140 miles of 8-in. pipe and 30 miles of 10-in. pipe. The new main line parallels the existing line from Caliola pump station to Martinez refinery, utilizing second line rights obtained at the time the original line was built, thereby greatly reducing the amount of new right-of-way to be acquired.



Interior of pump room, Bakersfield Station

The route selected for the line was the shortest distance between Bakersfield tank farm and Caliola, consideration being given to other areas of production to which lateral pipe line connections might be made in the future, and other important engineering considerations such as avoidance of improved agricultural lands, ease of transportation, and feasibility of construction.

Leaving Bakersfield, the line takes a general northwesterly course, passing near the Lost Hills and Kettleman Hills oil fields to Caliola, and through Kern, Kings and into Fresno County. From Caliola to Martinez the general course is still northwesterly, passing through Fresno, Merced, Stanislaus, San Joaquin, Alameda, and Contra Costa counties.

From Bakersfield to Shell's Merval pump station in Merced County, a distance of approximately 155 miles, the line passes through a generally unimproved plains country. From Merval pump station northwesterly to the Meganos pump station, in Contra Costa County, a distance of approximately 75 miles, the route passes through dry farming country, growing mostly wheat and barley. At Meganos pump station mountainous terrain is encountered near the eastern slopes of the Mt. Diablo range, where the highest elevation on the pipe line system is reached, approximately 1000 ft. above sea level, and 15 miles southeasterly from the Martinez refinery. At this point the line passes through highly-improved vineyard and orchard country, and drops down to practically sea level at the refinery.

All engineering, designing, surveys, selection and purchase of materials, and inspection was done by Shell Oil Company under supervision of the company's chief field engineer, J. R. Gignoux. Actual construction was performed under contract. As a result of careful planning, organization, engineering, and a splendid spirit of coöperation between the two groups working on the project, several interesting time records were made.

Outstanding performance was by the general contractors, Lindgren & Swinerton, who completed the laying of the new main pipe line and laterals (312.16 miles in all) in the remarkable time of 90 days. They also completed the four new pump stations and made additions to the other six in a similar period of time.

No serious accidents occurred to mar the record. Naturally, a few accidents of a minor nature took place, but in handling more than 26,000 tons of pipe from Los Angeles and Stockton harbors, over highway and railroad, and stringing it by truck along the predetermined 316-mile course, nothing untoward occurred, nor was a single highway traffic accident reported. This good record continued on through the erection of the new pump stations and all other phases of the work.

H. C. Price, Inc., of Bartlesville, Oklahoma, performed all welding operations on the project under the personal supervision of Mr. Price, whose crews made their first weld on July 22, 1936, on the main line, and the last firing line weld on October 21 at a point near Meganos pump station in Contra Costa County. Possibly the statement that the welding contractors made the last weld is inaccurate if we remember that the last, or "golden weld," was made, with appropriate ceremonies, by Shell's president, S. Belither, with the assistance of his manufacturing and marketing vice-presidents, C. H. Van Senden and W. P. Durkee.

The new system, including all laterals, was then thoroughly flushed with water previously accumulated in Bakersfield tank farm and pressure tested, the new main line pumps being used for this purpose. No leaks were found in the entire 316 miles of line.

At 8:00 a.m. on December 20 oil was started for the first time through the line from Bakersfield tank farm. The head of this oil arrived at the end of its journey at 5:15 p.m. on December 27 and a continuous stream of Bakersfield crude has been flowing to Martinez refinery ever since.

In designing this project, Shell's engineers had to plan a system that would be elastic enough to transport economically oils of various grades ranging from the lowest to the highest gravities. However, the most viscous oil was the controlling factor and the line was designed to operate most economically under full load moving the heaviest oils under extreme winter conditions and in order to do this it was necessary to provide a so-called hot oil line.

These conditions resulted in the selection of a 10-in. pipe line leaving each pump station, the diameter increasing to 12 in. about two-thirds of the pumping distance to the next station.

The 10-in. pipe on the discharge side of the pump stations weighs 34.83 lb. per ft. for a distance of approximately four miles, where it is lightened to 31.2 lb. per ft. to its junction with the 12 in., which weighs 37.45 lb. per foot.

This system of pipe line weights and sizes is used throughout the entire length of the line, thus compensating by a change in pipe diameter for losses in temperature and corresponding increases in viscosity as the oil progresses away from the pumping station.

Facilities were installed at the pump stations to heat the heaviest grades of crude to a temperature of 180 deg. fahr., and pump it at the rate of 1200 bbl. per hour at an operating pressure of 1000 lb. per sq. inch.

Eight-in. and 10-in. pipe used in construction of the main line and laterals is A. P. I. grade B seamless line pipe. The 6 in. and 12 in. were manufac-

tured by the electric-weld process, and also conforms to A. P. I. grade B specifications. National Tube, Republic Steel, A. O. Smith Corp., Jones & Laughlin, and Spang-Chalfant received the awards on pipe.

All pipe was beveled for welding at an angle of 37.5 deg. and all field joints were made by the electric arc method, each weld being built up in three beads. Field tests were accomplished by applying compressed air to a pressure of 180 lb. on complete sections of three to five miles in length, the welds being given the soap-water leak detection test.

Slack was provided in the 6-in., 8-in., and 10-in. sections of the line by use of the vertical "slack-wallop" and in the 12-in. pipe by "horizontal wallops."

In laying the main and lateral lines contractors used modern equipment throughout. Sufficient side-boom tractors of the Caterpillar type, ditching machines, and other necessary equipment, which included 40 arc-welding machines, were supplied to outfit four complete construction crews working simultaneously on different sections of the line. Original points along the line from which these four crews started were Bakersfield (all laterals), Bakersfield pump station to Caliola, Caliola to Meganos pump station, Meganos to Martinez. All crews finished surprisingly close together in the matter of time. The best day's run of any crew during the progress of this work was 5.25 miles of 10-in. line completely tied in. The daily average for all four crews was 3.51 miles of completed line.

State highways and railroads crossed, bored, and cased, together with county road and irrigation canal crossings, totalled 78. Each required special attention to conform to the regulations prescribed by local governing authorities.

In addition to these 78 crossings, two passages of the Kern River were made; one on the Ten Section lateral, the other on the Mountain View lateral. These were made in the orthodox manner; that is, river clamps were installed over each joint and bowed upstream to insure permanent burial under the river bed.

Two suspension-type bridge crossings were necessary. The first is across Big Panoche Creek north of the Cheney pump station. This bridge was constructed in 1914 to accommodate the existing pipe line with ample provision for taking additional lines. The second, across Los Banos Creek, two miles north of Merval pump station, is of similar design and was constructed as a part of the new line. It is 260 ft. long between suspension towers. Approved expansion joints were installed at each of these suspension bridges. Similar expansion joints were included on the line where it is exposed to the elements for a distance of 150 ft. or more. These expansion joints have proved necessary to hot oil line operation, eliminating entirely difficulties from expansion and contraction of the line at these points.

Expansion joints also were installed on the discharge side of all pump stations to protect station manifold and yard piping against undue strain from expansion or contraction.

The proper selection of pump station sites and the equipment to be used in those stations required careful consideration. On the section of line from Caliola to Martinez it was decided to use the existing crank and flywheel type of steam-driven plunger pumps as the main pumping units for the hot oil.

Additional oil heaters were installed at existing pump stations plus an additional boiler, and some minor changes were made in the auxiliary equipment, station piping, etc. Thus, station equipment and location of stations on this sector of the line was, more or less, predetermined.

It remained, then, to determine the proper lengths of 10 in. and 12 in. line to meet the conditions of pressure and temperature losses between the pump stations.

It will be seen that in the Caliola-Martinez sector of the system there are two parallel pipe lines: the old, or existing combination 8-in. and 10-in. line, and the new combination 10-in. and 12-in. line. The former is operated as a constant temperature light oil line.

In order to move efficiently the greatly increased volume of oil going through these two systems there was installed at each of the six existing stations (Caliola, Cheney, Merval, Stimba, Corral, and Meganos) one 237.5 hp. Heine type longitudinal riveted drum steam boiler without superheaters. Each of these boilers was installed in separate settings and fitted with a 38-in. diameter, 130-ft. welded smoke stack. The existing smoke boxes and stacks were insufficient to serve the new boiler installation. Each new boiler was equipped with Peabody type M combination gas and oil burners.

In conjunction with this new boiler installation, gas burner rings also were provided for the old Heine type boilers and fuel gas provided at all six stations instead of fuel oil, which previously had been used.

As existing old-style oil heaters were inadequate three new heaters were installed at each of the stations. They consisted of two 48-in. diameter by 20-ft. tube-length, low-pressure heaters, each having 6225 sq. ft. heating surface; and one high-pressure heater, 26-in. diameter by 18-ft. tube-length, with 1422 sq. ft. of heating surface.

Many interesting and novel features have been built into these heaters, but space limitations preclude the possibility of going into detail.

A 720-bbl., 40-ft. high floating tank is connected to the suction line between the outgoing side of the heater group and the pumps, thus insuring flooded conditions in both heaters and pump suctions. The in-

Unloading Pipe at Stockton Harbor

Suspension bridge over Panoche Creek

coming hot oil is connected directly to the cold side of the heater group.

There also was installed at each of the stations on the Caliola-Martinez sector a Byron-Jackson 4-in. by 6-in. 6-stage O. L. multiplex contrifugal pump, directly connected to a 390-hp. Westinghouse steam turbine. This unit is capable of delivering 1200 bbl. per hour against 800-lb. line pressure and is so connected that it may be operated on either of the two lines on either hot or cold oil. This latter feature also applies to the crank and fly wheel unit and the existing Jeannesville straight-line plunger pump, which will be maintained as a standby for the other two main pumping units at each of the six stations.

As the design of the original pumping and heating facilities provided for raising the temperature of a smaller quantity of oil to a maximum temperature of 140 deg. fahr., whereas the new line requirements were based on an operating temperature of 180 deg., with a greater quantity of oil to be transported, the steam turbine driven centrifugal pumps are calculated to provide the necessary additional exhaust steam to maintain thermal balance on hot oil side while actually these pumps are moving cold oil.

The originally installed heaters remain connected through a small floating tank and are used to maintain a constant low temperature on all oils moving through the original light oil or cold line from Caliola to Martinez.

Small structural additions to each of the pump buildings were made, also a vast amount of changes to the suction discharge and auxiliary piping. All of this work was accomplished with the existing line in operation except for three shut-downs—two for 12-hour periods, the third for 30 hours.

The four new pump stations (Bakersfield, Wasco, Mid, and Kettleman) on the Bakersfield-Caliola sector are, in most respects, identical and equipped with the finest equipment available. As previously stated, they are designed to handle a peak capacity load of 1200 bbl. per hour of the heaviest crude at a 180-deg. temperature against 1000-lb. pressure under extreme winter conditions. To accomplish this each station is provided with three Ingersoll-Rand 4-stage, 6-in. centrifugal pumps driven by a 350-hp. Moore steam turbine. Steam is supplied by three 237.5-hp. Heine type boilers supplied by Combustion Engineering Company, Inc., equipped with superheaters operating at 200-lb. pressure and 100-deg. superheat.

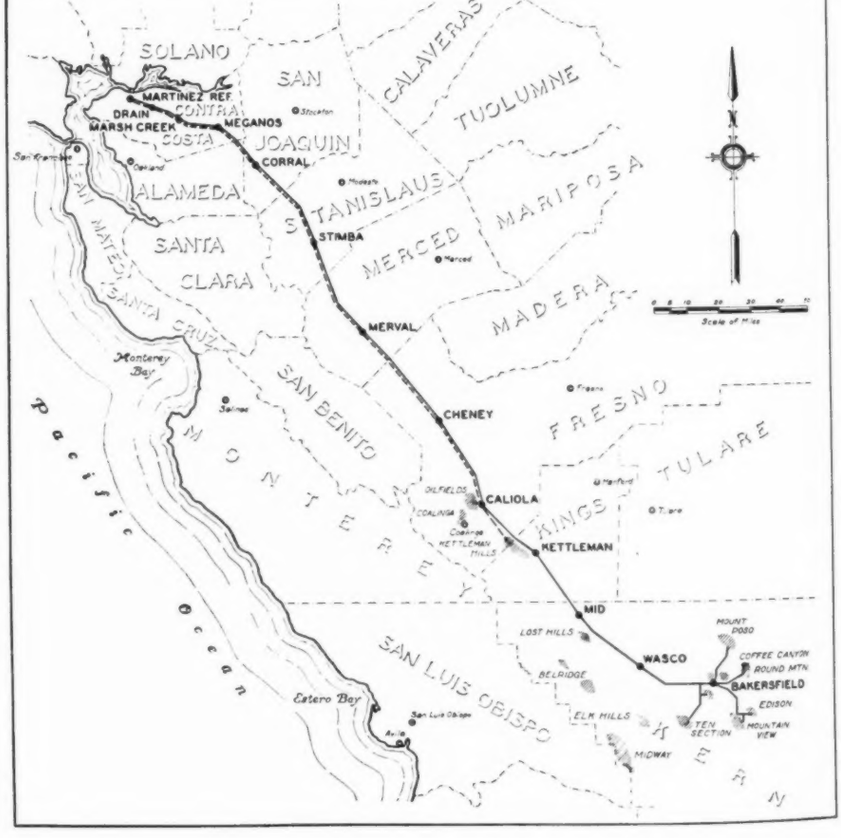
Each boiler is equipped with gas and oil burners, similar to those previously described on the Caliola-Martinez sector, and a single smoke stack, 54 in. in diameter by 130 ft. high.

Auxiliary equipment includes two Ingersoll-Rand 2-stage, 80 gal. per min., 275-lb. pressure, centrifugal boiler feed pumps and two 80 gal. per min., 70-ft. head, feedwater heater supply pumps, mounted on a common base, together with their steam turbine drivers. These operate in conjunction with an Elliott de-aereating feed water heater having a heating capacity of 30,000 lb. of water per hour from 140 to 219 deg. fahrenheit. Feedwater regulators control boiler feed.

A 7-in. by 5-in. by 10-in. duplex steam driven pump is provided for general utility service and a 2½-in. centrifugal pump with a capacity of 300 gal. per min. against total pressure of 150 lb., driven by a General Electric 47-hp. steam turbine, is provided as a fire pump.

A fuel oil burner pump and heater set manufactured by Coen is provided to supply the boilers when operating on oil.

The above-described principal equip-



Shell Oil Company's San Joaquin Pipe Line System

Making a weld on 12-in. line north of Caliola

ment on the four new stations, Bakersfield-Caliola, is housed in four structural steel frame, corrugated iron buildings, 59 ft. by 100 feet.

The boilers and all auxiliaries are separated from the main pump room by a fire-proof wall. A small office is so situated that an operator has clear vision of both main pump and boiler room compartments. In this office the main gauge and instrument board is installed. An instrument board also is mounted in each of the main pump and boiler compartments upon which indicating gauges, particularly adapted to controlling the equipment in each of those compartments, is mounted.

Main oil heaters, in all respects similar to those installed on the Caliola-Martinez sector, are used at these four stations. The heaters are installed outside each main building and are provided with a raised platform, or catwalk, to make accessible all valves and fixtures.

In order that the greatest fuel economies would be realized in the operation of these plants, auxiliary equipment was provided so that during periods of exhaust steam surplus not required for raising or maintaining the temperature of the oil being pumped, the entire plant may be operated full condensing. This is accomplished by use of a jet-type air pump capable of maintaining a high vacuum on the main oil heaters and an automatically-controlled, electrically-driven condensate pump.

Appropriate drain sump and hot well facilities are provided outside the building and wherever possible piping is placed above ground or in open trenches. Inside the main building all piping is exposed in concrete trenches having steel floor-plate covers.

At the Wasco, Mid, and Kettleman stations no floating tanks are provided. The incoming stream of oil is directly connected to the main pump suction, so arranged that the oil may be diverted directly to the pumps without passing through the heaters, or vice versa. The main pump steam turbines are equipped with pressure governors so regulated that a back pressure is maintained on the oil heaters or suction sufficient to insure flooded suction conditions and automatic regulation of pump output in step with the upstream station; Bakersfield pump station output being manually controlled.

Wasco, Mid, and Kettleman stations are each equipped with two 15,000-bbl. A. P. I. steel service tanks; two 1000-bbl. steel water storage tanks, and two 144-bbl. steel fuel oil storage tanks.

At Bakersfield pump station there are two 144-bbl. steel fuel oil storage tanks and two 1500-bbl. steel water tanks, the latter serving the tank farm, the pump station and the new office building and camp, which also were recently constructed and put into operation. Because of the obvious necessity of collecting ahead and temporarily storing the crude coming in from the laterals, a complete and new tank farm was erected, strategically located some five miles north of Bakersfield.

At the tank farm six 68,000-bbl. A. P. I., 102-ft. diameter, eight rings high, welded bottom, riveted shell, and welded cone, roofed tanks were erected; also two 68,000-bbl. tanks of similar specifications except that these two were equipped with Wiggins pontoon roofs. This made a total gross storage at Bakersfield tank farm of 544,000 barrels.

The tank farm site is so situated on gently sloping ground that the tanks provide a suitable gravity head on the pump station, connected to the tanks through a large diameter suction pipe system, inclining gently upwards to the tank farm.

At Caliola tank farm two 68,000-bbl. tanks with pontoon roofs were added to the existing storage at that point which consisted of seventeen 55,000-bbl. steel tanks erected in 1914.

A suitable supply of good water was obtained at Bakersfield, Wasco, and Mid, from water wells drilled on or near the pump station site. These water wells are equipped with submersible electric motor-driven pumps, automatically controlled.

At Kettleman station water was obtained from a local water company.

The company's existing telephone line system was extended south from Caliola, via the pump stations, terminating on a switchboard in the new Bakersfield office building. Between Bakersfield office and Shell Building, Los Angeles, two No. 9 copper circuits were constructed, thus giving ample facilities between the latter offices for necessary pipe line and tank farm operation; control between all pipe line stations and the dispatcher's office in Los Angeles, as well as taking care of general communications for production, marketing, exploration, and other departments of the company. This provides an ample and continuous service between Martinez refinery on San Francisco Bay and Shell Building, Los Angeles, serving all pipe line pump stations, tank farms, and field operating offices enroute.

Attractive 5-room modern cottages for married employees; a 9-room dormitory with every convenience to accommodate unmarried station employees, and a specially-designed boarding house were erected at Wasco, Mid, and Kettleman. Bakersfield pump station being but five miles from the city, no accommodations were provided at that point.

The elapsed time taken for the engineering, design, purchase, and delivery of equipment, and hauling, erection, and construction on the project, was slightly more than seven months. The number of men working was approximately 500. The cost involved was slightly in excess of $4,500,000.

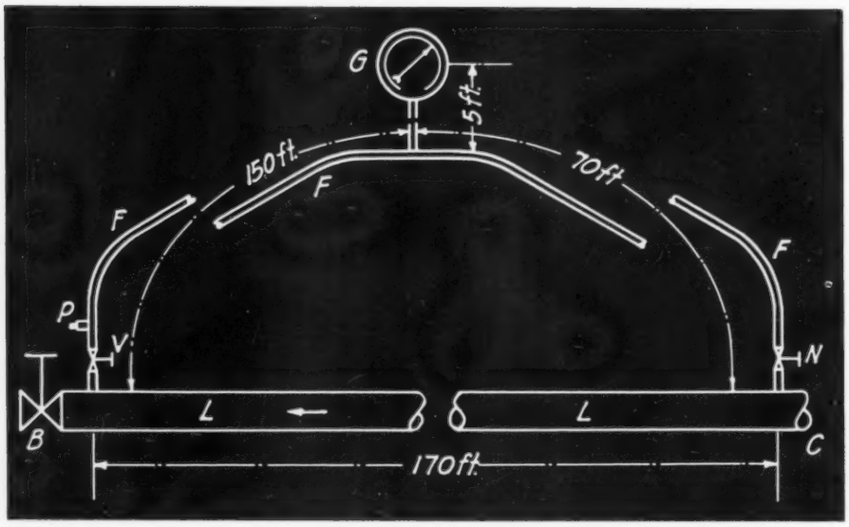


Fig. 1. Schematic layout of loop for freeing gauge from choke effect of paraffin deposited in small pipe connecting gauge with pipe line. B—Main line gate. C—Tie-in of loop. L—Main line. N and V—Needle valves. P—Clean-out plug. G—Gauge. F—Loop

Paraffin-Free Gauge Hookup

When pressure gauges at a pipe line station failed to register accurately a check-up was made to determine the cause and provide a remedy

By ELTON STERRETT

LAG of the station recording gauge behind indications on the gauges that are mounted as closely as possible to individual pump discharges was attributed to the loss of head in the 150 ft. of ½-in. pipe connecting the chart instrument into line pressure just short of the main line gate.

When the relief valve opened under excessive pressure on three occasions and filled a 30-bbl. sump from the line before the pressure change made itself evident on the recording gauge and thus warned the station engineer, a careful check of all pressure gauges was ordered. Upon inspection, the chart indicator showed a 5-lb. overage against the standard weights on check, and was a like amount above the relief valve when it, too, was scaled for actuating pressure.

Considering the possibility that the ½-in. line tying in gauge and main line might be clogged, the union just below the recorder was cracked, and free oil seep obtained. The gauges were then replaced and once again the sump filled before the station instrument indicated a pressure rise sufficient to actuate the dead-weight relief valve. As the station was running under a special permit from the main office to operate on 860 lb. initial line pressure instead of the standard 780, it was necessary to set the relief with practically no margin, and still work at the desired maximum.

Checking again into the hook-up, the ½-in. line was disconnected at the tie on to the main line, and air pressure applied. A slight volume of oil had trickled from the open end before the air line was connected, but under a pressure of 250 lb. no flow was obtained through the opened gauge union. After fitting a temporary drain to the station pit and again putting the line on main pressure, the trouble was evident. A solid column or core of paraffin was extruded from the pipe, some of it—at an atmospheric temperature of 45 deg. fahr.—being so hard as to peel off in flakes.

The initial test flow, obtained when the union at the gauge was cracked, was that of the oil in the stub end within the station, warmed by room temperature to approximately 70 deg., and hence fluid. Had the union been allowed to remain open a little longer, the first of the solidified paraffin would have appeared, and the trouble discovered at that time.

To avoid paraffin deposition in the gauge line, or at least to insure flow through it in the direction of oil travel through the main line, the 8-in. was tapped at point "C", (see Fig. 1), as close to the station as possible, and a loop of ½-in. pipe laid to connect this tap at "C" with the original gauge fitting in the main gate pit at "B."

A 5-ft. riser tied in the recording gauge on this loop at a point 70 ft. from "C" and 150 ft. from "B." Then, with the needle valves "N" and "V" cracked, the pressure rise was watched and checked with that of the nearest of the pump gauges; and then, when no spread in readings was noted, against the opening of the relief valve when the maximum pressure was deliberately exceeded. Again the recording gauge was checked, this time far enough in advance of the relief opening to permit a pump to be slowed and the cut back avoided.

The theory upon which the loop was installed involves the surge set up in the line at each plunger stroke. Under a line pressure of 860 lb., a peak of 1600 lb. following each plunger impact—assuming full air cushioning of the line—may be imposed upon the system for a fraction of a second, followed by a drop in pressure below line average to perhaps 500 pounds.

At peak pressure more than the normal flow of oil is forced through the restricted area of the opening in needle valve "N" and momentary acceleration of flow through the line thus obtained. At the ensuing drop in pressure practically none of this "distress" oil, forced through by the peak pressure, finds its way back, due to the restriction in the pinched valve, and flow then must continue through the ½-in. line in the direction of "V" and the main line.

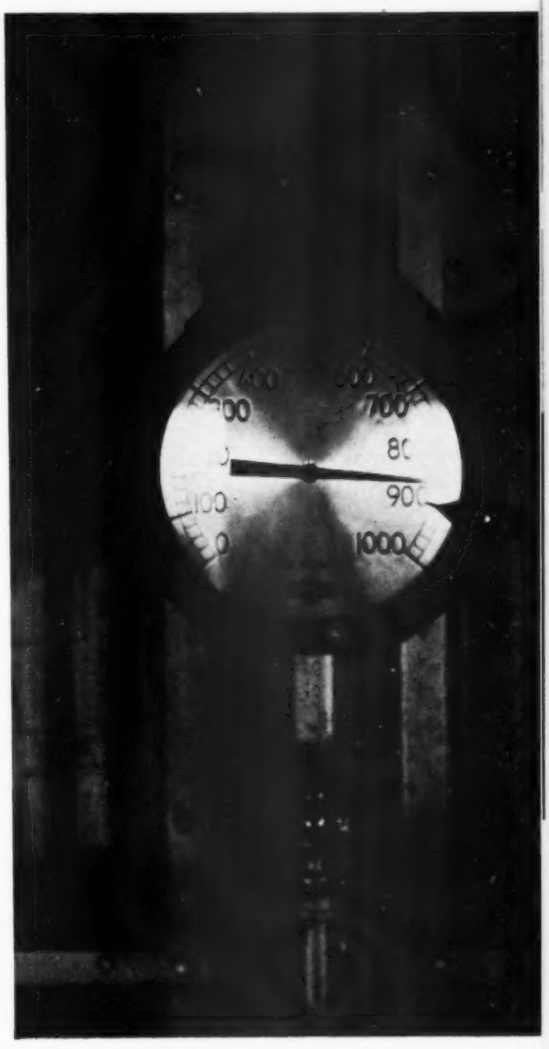
Due to the length of main line intervening between the ends of the gauge loop, the pressure peak at "V" does not coincide with that at "N", as there is 170 ft. of main line through which the pressure wave first must travel. As the velocity of this wave in East Texas crude has been determined at 3863.2 ft. per sec., the peak can not reach "V" until approximately 1/20 of a second after pressure in the other end of the gauge line has been boosted by the peak at "N." Due to this delay or lag in peak incidence, flow through the gauge loop consists of a series of minute pulsations paralelling flow in the main, by means of which the ½-in. pipe is kept free of dead oil in which paraffin deposits much more rapidly than when flow keeps the fluid turbulent and prevents the paraffin flakes from coalescing.

Connecting the gauge as shown in Fig. 1 permits the expanse of ½-in. pipe to act as attenuated shock eliminator and the alternate pulsations from either end to dampen out or neutralize each other, with practically no disturbing effect on the recording instrument.

As a test of the efficacy of the loop for suppressing line vibration a gauge from one of the pumps was taken, without change of the fluid valve, and tied in on the loop. Although at its position near the pump the hand had oscillated through a 10-lb. arc at each plunger impact, a photograph was taken whose time of exposure covered a period of 90 seconds. The sharpness of outline of the gauge hand in the view, Fig. 2, is proof of the absence of pulsation at the gauge, although, with two tandem duplex pumps delivering into the line, there must have been 480 distinct plunger blows on the stream during the interval the camera lens was open.

Installation of a plug at "P," Fig. 1, permitted the theory to be tested by needle valve "N" being closed and pressure from the line allowed to reach the gauge only via "V." After six weeks' operation in this manner "V" was closed, the plug removed, and "N" opened. As expected, paraffin issued through the opening at "P," although after a year's operation with both needle valves in use and the gauge "floating" on the loop, no paraffin was obtained when the line was blown clear.

Fig. 2. A 90-second time exposure of gauge on new set-up, in which sharp outline of hand proves suppression of pulsation from pump plungers



Preservation of Well Samples from Texas Fields

THE University of Texas is endeavoring to preserve adequately cores and cuttings from wells in Texas. A collection of well samples, begun by the Bureau of Economic Geology about 25 years ago, has now reached large proportions and recently has been increased by several gifts. The principal recent additions to this collection are as follows: from the Gulf Oil Company, Houston, during 1936, about six and one-half tons of well cuttings and cores, an estimated total of 125,000 samples; from the Seaboard Oil Corporation, Dallas, November, 1936, cuttings and cores from a deep well in Hamilton County; from the Skelly Oil Company, Houston, December, 1936, about 1500 lb. of cuttings and cores from wells in the Bay City field in Matagorda County. In addition to these collections the Board for Lease of University Lands, in connection with its work in West Texas, has assembled a large collection of samples from wells in the Permian basin, an estimated total at the present time of about 225,000 samples. The entire collection assembled by the University up to the present time is probably near 1,000,000 well samples.

Other and larger collections will be given to the University in the near future if such can be adequately cared for, and efforts are being made to provide for the permanent preservation of these valuable records. These well samples, which are certain to be of great value to the petroleum industry in the future, can be made most useful if stored in a fireproof building and catalogued so as to be readily accessible. If preserved at all they must be obtained as the wells are being drilled. Many millions of dollars are expended each year in exploratory drilling, the results of which, if preserved, will be of great value in the future.

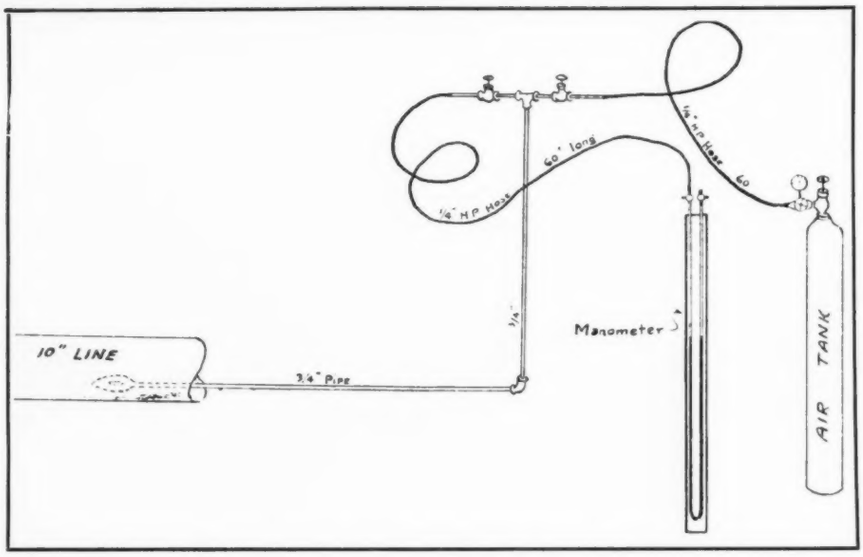


Fig. 1. Schematic diagram of connections, Baytown crossing survey

Prospective deepening of Houston Ship Channel made it necessary to determine depth and location of six oil and gas lines laid beneath its bed

Depth of Lines Crossing Channel D ete

DUE to the prospective deepening of the Houston Ship Channel to a maximum contract depth of 37 ft. at a point where six oil and gas lines cross under it, the necessity arose for accurately determining the depth and location of these pipe lines.

Originally six high-pressure gas mains yoked together were laid by the Houston Pipe Line Company at this location, but two of these lines subsequently were sold to the Humble Oil and Refining Company for transporting oil and gasoline beneath the channel. Since both companies were involved, a joint survey was undertaken.

The Humble Pipe Line Company was represented in this work by A. E. Pecore, assistant civil engineer, and Edward M. Chapman, mechanical engineer. The Houston Pipe Line Company was represented by C. P. McKnight, civil engineer, and David Harrell, corrosion engineer.

It was decided to triangulate in order to locate accurately the points where the lines emerged from the channel in respect to United States engineers' reference stations. Accordingly, two base lines were laid down on opposite banks of the channel and accurately chained in order to eliminate any possible error from this source. Humble engineers set up on one side of the channel and the Houston Pipe Line Company engineers on the other, and all angles between stations were turned five times for accuracy.

Fig. No. 2. No. 1 line being tested.

Since the minimum depth below mean low tide to the top of the outside lines was the vertical distance desired, it was decided to attempt to measure accurately the hydrostatic head inside the lines at various regular intervals. It was decided further to cut the two outside gas mains and fill

Fig. 3. No. 4 gas line cut. Small gasoline engine used to fill line is shown

Fig. 4. All hands trying to start pump

By

DAVE HARRELL

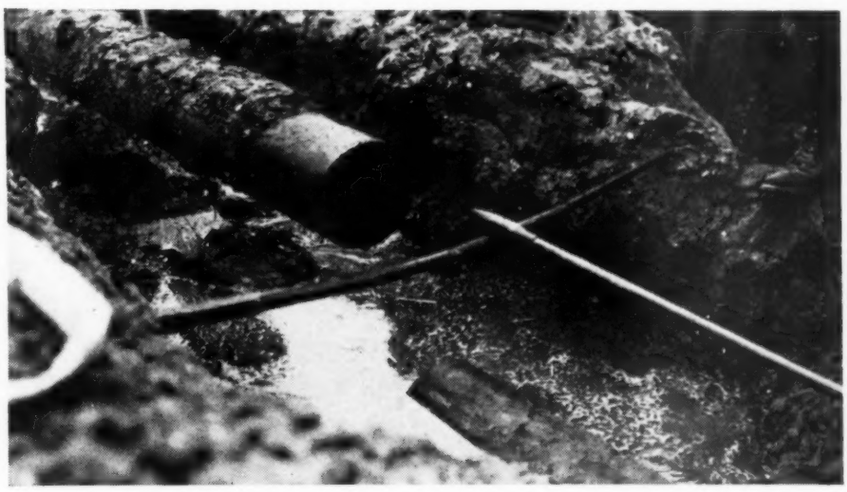
D etermined by Head Pressure Method

them with water in order to make these measurements.

Fifteen hundred feet of ¾-in. galvanized pipe and collars was assembled, and a small gasoline-driven centrifugal pump, for filling the lines with water from the channel, was obtained; also, a special ¾-in. bull plug was constructed to fit over the end of the pipe. This bull plug was beveled on either end to prevent its hanging up on any "icicles" from welds that the end of the small pipe might encounter on its trip through the 10-in., and slits were cut in it to admit the water but to prevent its stopping up by any sediment or other foreign matter that might be encountered inside the lines.

A 50-in. manometer, two pieces of high-pressure welding hose, two large cylinders of compressed air containing approximately 220 cu. ft. each,

Fig. 5. Close-up of special bull plug on ¾-in. line



a welder, and all welding materials, were transported across the ship channel to Alexander Island.

It was thought best to conduct operations from the Alexander Island side of the Ship Channel, since the proposed cut passes within 460 ft. of that side. The two outside gas lines were cut and the ¾-in. pipe made up and pushed into them a total distance of 1000 feet. Readings were made at this point and every 20 ft. thereafter as the pipe was withdrawn.

Fig. 1 shows the manner in which the air bottles and the manometer were connected up. To take a depth reading, it was necessary to close the stopcock shown in the hose line leading to the manometer and open the one in the hose leading to the air bottle. Air was then blown into the ¾-in. pipe until all the water was expelled from it and no further rise in pressure was indicated on the gauge mounted on the bottle. The stopcock in the hose leading to the air bottle then was closed,

Fig. 6. Air bottle, and manometer connections

Fig. 7. Welder at right is putting No. 4 line back together while No. 1 line is being surveyed

Fig. 8. Water being blown from line with gas pressure

and the one in the line from the manometer opened. This allowed a reading to be made on the manometer. Some difficulty was experienced, since the system acted as an "air-lift," and the air rising from the end of the ¾-in. pipe caused the water to run from the 10-in. pipe in considerable volume. It was necessary to start the pump and refill the line on several occasions due to the operation of this "air-lift." The surging of the water in the 10-in. pipe caused some difficulty in reading the varying pressures on the manometer. It was sometimes necessary to wait several minutes until the system had come to rest before an accurate reading could be made.

Fig. 2 shows all six lines at the point on the island side where they leave the water. No. 1 gas line is shown cut and pulled up with the hoist, while the two oil lines of the Humble Pipe Line Company lie to the left of the hoist. The boats in the picture were those used for transportation on the job. On the opposite bank of the channel and in between the white boat and the tripod may be seen a large white sign that marks the spot where the oil and gas lines leave the water on the mainland side.

In Fig. 3 No. 4 gas line has been cut and filled with water, and the ¾-in. pipe inserted to a total distance of 1000 feet. In this same picture may be seen the small gasoline engine used to fill the lines with water from the channel.

Fig. 4 shows all hands trying to start the small 2-cycle engine that developed a bad case of temperament, due to cold weather that prevailed while the job was in progress. The man with his back turned is A. E. Pecore of the Humble Pipe Line Company.

Fig. 5 is a close-up of the bull plug screwed on the end of the ¾-in. pipe. Shown also is the flat section tacked on the bottom half of the 10-in. pipe to keep the water from running out so badly while readings were being made.

Fig. 6 shows the air bottle and manometer hook-up and some of the ¾-in. pipe used. When this picture was taken the survey on No. 4 line had just been completed, and the operations on No. 1 line about to begin. Readings were made every 20 ft. as the ¾-in. pipe was removed from the 10-in. line.

In Fig. 7 the welder is putting No. 4 line back together, while the ¾-in. pipe is being run in No. 1 line.

Fig. 8 shows the water being blown from one of the lines with gas pressure after the survey had been completed. It was conceded by all that the water in the Ship Channel would be brackish, and due to the depth of the channel would be stratified according to gravity if left quiet and still. The heavy ship traffic in and out of the channel, plus the strong currents set

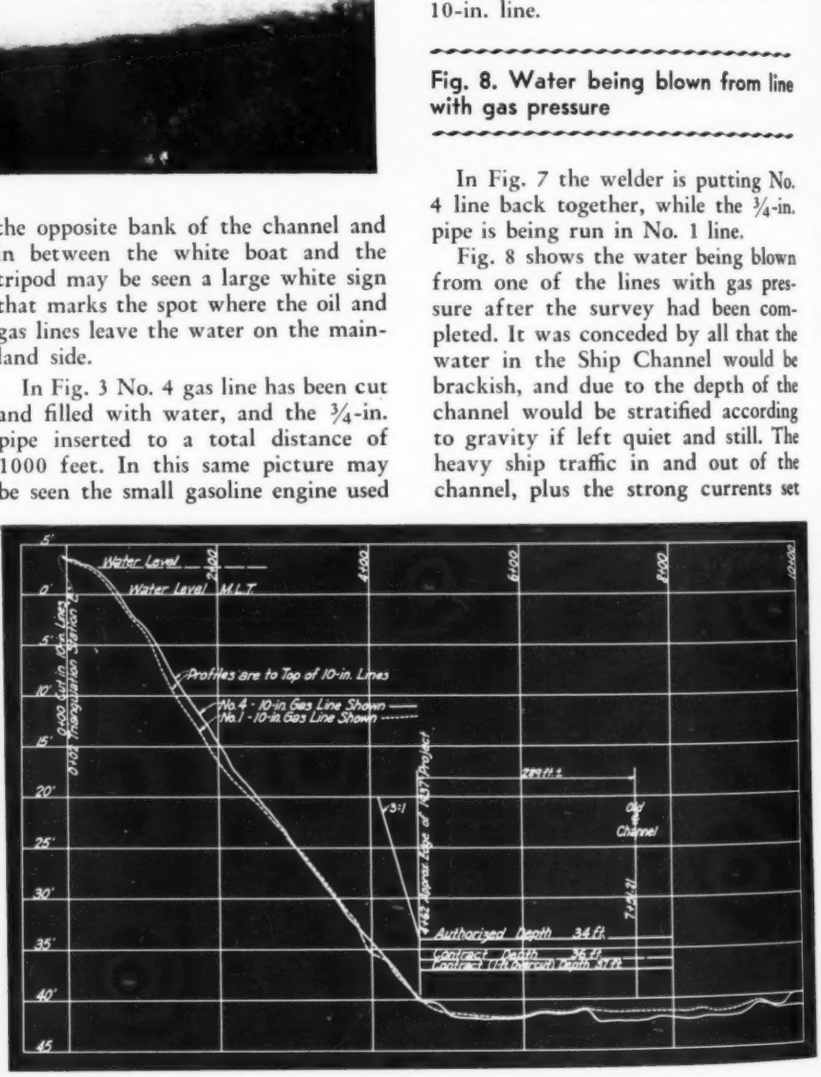

Water Level
Water Level M.L.T.
Profiles are to Top of 10-in. Lines
No. 4 - 10-in. Gas Line Shown
No. 1 - 10-in. Gas Line Shown
Old Channel
Authorized depth 34 ft.
Contract depth 36 ft.

Fig. 11. Profile of line crossings of Houston Ship Channel
Scale: 1 in. horizontal = 80 ft.
1 in. vertical = 6 ft.

Fig. 9. It can't be done this way (See text)

up by ebb and flow tides, provides such excellent agitation at all depths here that the water at any level was found to be practically the same as that below or above.

Fig. 9 shows the two small boats attempting to tow the ¾-in. pipe out into the middle of the channel. It was thought an excellent idea to calibrate the readings directly and convert inches of mercury into feet of water, thus establishing a conversion factor for the particular kind of water under the conditions prevailing at the time of the survey. It was found, however, that while the pipe could be pushed and towed out a distance of 300 ft., the unsteadiness of the boat rendered the measurements of depth very inaccurate, and the data acquired in this manner for calibration purposes were discarded. It was then decided to establish a multiplier by lowering the bull-plugged end of the ¾-in. pipe from the Humble company dock where a depth of 35 ft. of water existed.

Fig. 10. The manner in which the calibration was made

Fig. 10 shows the operations being conducted from this point. From a handbook of chemistry and physics, it was found that pure water yields a factor of .0736 in. of water per in. of mercury, or 1 in. of mercury equals .8832 in. of pure water; hence, if in. of mercury were multiplied by the reciprocal of .8832, we would have a conversion factor of 1.132. Since the third decimal place made very little difference, a factor of 1.12 was adopted by all and calculations made. The following is a table that checks this figure very closely and was compiled from the direct readings made on the Humble company dock, as shown in Fig. 11.

A sample of surface water from the location of the pipe lines was found to have a gravity of 1.017, and dividing the factor for pure water by this gravity correction yields a factor of 1.12 as multiplier.

CALIBRATION FACTORS

Measured Depth Ft.	Total Height of Hg. In In.	Conversion Factor	Reciprocal
20	17.95	.8975	1.114
25	22.4	.8960	1.116
30	26.9	.8967	1.115
Average Recip. . .			1.115

The weather was quite cool when these measurements were made, and there was so little difference between the temperature of the water in the pipe and the mercury in the U tube that temperature calculations were disregarded as too minute to become measurement factors.

The results obtained from this work checked within six inches of what the depth was thought to be and so have been accepted as correct.

Figs. 11 and 12 show the cross-sections constructed from calculations made from observations as described under a discussion of Fig. 1.

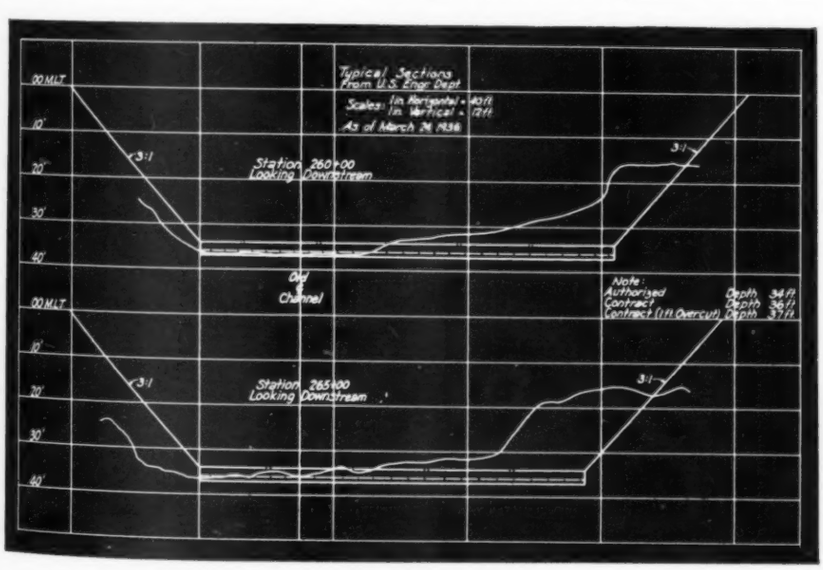


Fig. 12. Typical sections of the channel at two stations showing the position of the lines

Drilling Well Lost in Lake Maracaibo Goes on Rampage

Its Spectacular Performance Ends in Demolishment

AN unusual occurrence, depicted by the accompanying illustrations, was the complete loss of a well in Lake Maracaibo, Venezuela, while drilling for oil in the lake bed. The test was being drilled 3281 ft. offshore and came in unexpectedly at 1860 ft. while the 6-in. drill pipe was being pulled. Although the hole was full of mud, pressure was so great that the pipe could not be lowered to close the blow-out preventer.

Gas and oil ejected from the well under pressure undermined the piling upon which the derrick and machinery were erected. A cavity was formed. The derrick slowly subsided as the cavity below grew larger. The accompanying pictures tell the graphic story.

For these remarkable pictures and accompanying information we are indebted to the *U. S. Steel News* and The National Tube Co.

Fig. 1. This photograph shows the gas and oil shooting up through the derrick in a spectacular manner. Eventually the entire structure was undermined, causing it to topple. The drilling crew escaped from danger in a launch.

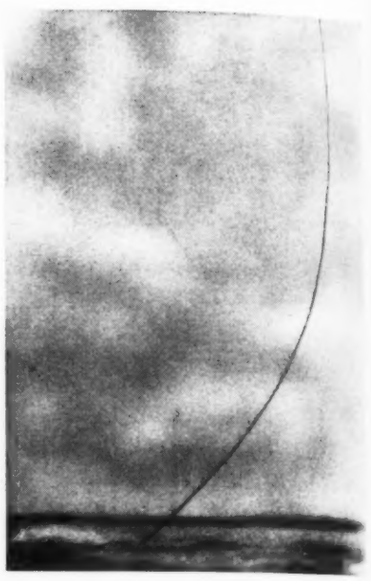


Fig. 5. The drill pipe is shown falling back into the water. Examination of the entire length of drill pipe, which was National 6-in. seamless steel interior upset, failed to disclose a single fault or fracture.

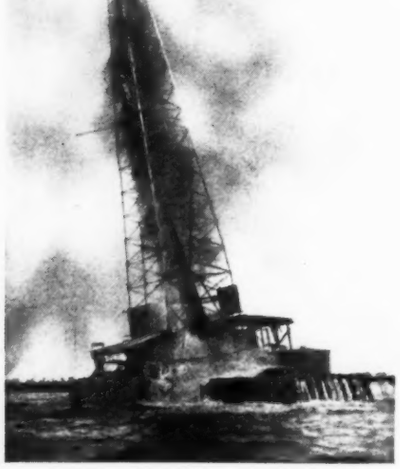


Fig. 2. As the derrick began to fall the drill pipe, forced from the hole, caught under one of the girts and the whole remained in the position shown here for one and one-half hours.

Fig. 3. The falling derrick carried the drilling machinery with it into the lake, at the same time freeing the drill pipe, which immediately was blown into the air, the total length of the pipe being 1100 feet.

Fig. 4. When the derrick collapsed the end of the drill pipe, still in the hole, was forced clear and straightened out in the air to a height estimated at 800 ft., and upon falling narrowly missed the crew in the launch.

Petroleum Economics

Net dollars and cents or just barrels and gallons? — Economics and engineering can help solve this problem

By CAMPBELL OSBORN

TWENTY years ago the problem was to find and produce oil. Profits were a matter of course. Prices rose. The shortage gave way to overproduction. This problem was solved —at least temporarily.

For the past several years the problem has been to make money from the superabundant yield. Prices have been ruinously low. Only a part of the excessive production has been absorbed. Efficiency has increased. Profits have reappeared for some; others are hopeful. But the new problem has been only partially solved, and to make money may be still more difficult when the tide comes in again.

What has brought about this reversal of conditions? Has it been the efficiency of the oil finder and his corps of geologists, geophysicists, and production engineers? The writer believes it has; but they must be kept at work, for the abundance of today may become a shortage tomorrow.

What can the unhappy oil man do to gain for himself a fair profit, and what can the whole industry do to take a new step in the march toward a safe permanent margin? Does not the answer partially lie in the wider use of economics and economic engineering? And if the oil man has more work of this character done for him, will it do for his balance sheet what the scientist and production engineer have done with his runs from wells and his runs to stills?

There is nothing revolutionary about the use of practical economic principles in business. For decades industrial executives have, consciously or unconsciously, made almost daily application of them. Some companies have spent large sums for business counsel, and others maintain departments engaged solely in economic and statistical work. The names of men employed in this sort of work long have appeared on the payrolls of members of the stock and commodity exchanges, of bankers, and of large investors. The war quickened national interest in the subject. The recent great depression with its accompanying surplus of nearly every commodity has further increased this interest. In the oil business hundreds of engineers have been hired to reduce costs, and recognition of the practical use and value of economics and engineering is growing steadily.

CAMPBELL OSBORN

This is the first of a series of articles on the economics of petroleum prepared by Campbell Osborn for publication in *The Petroleum Engineer*. Mr. Osborn, who is the author of "Oil Economics," in this first article discusses the uses and value of economic work in the oil business. His geological training, his legal experience, his work as compiler of the first statistics of the United States Geological Survey from 1917 to 1920 on current petroleum demand and supply, and his service for many years as adviser to a major oil corporation and as manager of a royalty company, qualify him to write authoritatively and interestingly on the practical aspects of this subject as applied to producing and refining operations.

The New Economics

Some of the things learned from economic experience are as old as Adam Smith, but the oil world of today is not and will not again be what it was even less than a quarter of a century ago. Modern conditions have given rise to new interpretations of old facts and have necessitated the formulation of entirely new principles and practice. The work is no longer confined to studies of demand, supply, and price, and the feeling has spread that there is more use for economics in the production and refining departments of the oil companies.

The Lamp of Experience

Oil men no longer call what controls the price of their products the "law of supply and *demand*." They have put the horse where it belongs, before the cart, and it is now the "law of *demand* and supply." They recognize that the best long range yardstick of what the supply will be is the amount of oil the consumer will buy. They think in terms of cost and price, not volume, and they know from bitter experience that net *dollars* and *cents* are more important than barrels and gallons. They know that the day of the "Lucky 7" oil company is gone forever. All have learned what the elder Rockefeller, bookkeeper as a boy, knew many years ago when, impassive with the announcement of a big gusher, he threw his hat into the air with the news that one of his men had reduced by the fraction of a cent the cost of putting 42 gal. of oil in a wooden barrel. Hardly a seasoned Mid-Continent producer is to be found now who does not know that the famous Burbank field and many other major pools are still in the red, and that more money has been spent in the finding and lifting of oil, even after allowing for the present worth of the producing leases, than the sale of it has netted their operators.

Nor have the refiners and marketers closed their eyes to the lamp of experience. They too have been stimulated by the great difficulty of making money under modern competitive conditions, and they are going to the trouble and expense to find out why and how to meet it.

Bringing the Lesson Home

The conditions that are responsible for this marked change in the views of oil men date from 1916. Four years earlier Cushing had been discovered and gushed forth its flush oil. In a few years it settled down to slow pumping and passed on as a market factor. This field was drilled with feverish haste and the gas pressure was soon lost with the abandon of dissipation.

Came then America's entry into the World War and the rapid rise in the use of the motor car. Demand shot upward.

The old-fashioned oil man and the few geologists then employed were not immediately equal to the occasion, and the storage barometer dropped abruptly. The alarm was first sounded by the United States Geological Survey. Said they, "the peak of production has been passed," and they looked with anxiety upon the mounting curve of consumption and the lagging figures on production. Voicing the concensus, Walter Teagle told the American Petroleum Institute that an oil famine was in prospect. Both the Government's geologists and those of the oil companies and men in private practice reviewed the reserves based on known geology and pronounced them inadequate for half a generation. They are not to be criticized. They were able men and their judgment was almost unanimous.

Spoke then the fundamental law of economics. Prices rose to $3.50 a bbl. in Oklahoma and to $6.00 in Pennsylvania. Practically every barrel of oil brought to the surface was sold for more than it cost, and even the skimmers could rely confidently upon a good margin between their costs and the selling prices of their refined products. No economist or engineer was necessary to make profits. What was needed was more oil and that meant better finding methods.

Action was not long postponed. Geologists by the hundreds were employed by the oil companies. Came later geophysics. In a comparatively short time oil-finding was revamped and revolutionized. After these scientists got under way new areas hitherto considered unfavorable or relatively unknown geologically, were examined and more major pools were discovered in ten years than during the entire preceding history of the industry. The shortage had given way to an abundance not before known.

Again spoke the fundamental law of economics. The price structure collapsed. Profits narrowed or disappeared; and thus was laid the foundation for new conceptions of economics and conservation, new uses for engineering, and expanded practical work in these fields by the oil companies.

The Industry's Price Position

If executives knew exactly what the price of crude oil would be for several years in advance it goes without saying that the new investments they make and their methods of management would be influenced largely by that knowledge. If they could rely upon specific prices for even six months or a year it would be a great boon to them. They could buy with confidence and foresee their profits.

No man can do this. Yet the estimates must be made. No man knows where oil will be found in wildcat territory, but test wells must be drilled. Few of such wells are drilled now without advance geological information. The oil producer no longer pours his money into a hole in the ground on hunches. Are not carefully prepared economic data, charts, and recommendations worthy of similar consideration by oil men before they make more important decisions? For instance, a large leasing or drilling program, expansion, retrenchment, additions to storage, reduction of inventories, the location or enlargement of a refinery, the erection or purchase of marketing stations? Are not studies justified that will be helpful in estimating prices and profits that may reasonably be expected and comparing them with probable costs, and all this before hundreds of men and millions of dollars are put to work? The oil man may bet a hundred thousand dollars on a wildcat well, but some often stake all they have on the price of petroleum.

The judgment of the executive of course will be final, but will not that judgment be better if his broad general picture of the situation is fortified by the work of a specialist? The most competent economic work can not be expected to predict specific future prices, but good work of this character shows the trend of demand and supply long enough in advance and with a sufficient degree of accuracy to be useful and indicates when prices *should* be changed. As shown by 30-cent oil in 1931, *the longer a sound price change dictated by the relation of demand to supply is postponed the more inevitable it becomes and the more drastic it will be.* Difficult as it is to say what the price of oil will be, everywhere that a barrel of oil is being brought to the surface and a gallon of gasoline is being consumed the forces of economics are counting them for or against the oil man, and, right or wrong, the turn must be called by boards of directors.

Forecasting Oil Prices

It is easy enough to say that reliable price estimates can be made, but before the oil man will spend money on the solution of problems he has long depended upon his own judgment, tempered by the opinion of other executives, to unravel, he must be shown. It must be proved to him that his judgment on the future price of oil requires the same bolstering with specialized work that the opinion of the old-fashioned oil producer needed from the geologist to help him locate new pools. The oil man knows from experience what a whale of an undertaking it is. He knows how hard it is to see underground, but the price estimator also must look into the future. It is the most stubborn problem in economics. But let's get down to earth.

The position and requirements of individual companies may temporarily postpone or accelerate a price change, but not for long. General conditions are the weighted average position of all companies. Demand is the important thing. Demand turns the wheels and pulls the rods. It is made up of the domestic consumption of refined products and exports of crude and refined oils. It can be accurately estimated for six months and the trend determined for a longer period.

The demand for oil is based on the capacity and disposition of the consumer to buy. There is no great difficulty in ascertaining the number of each class of the consuming agencies that use oil, the motor cars, trucks, buses, airplanes, oil heaters, Diesel and other heavy oil engines, tractors, rural homes where kerosene is used, and other channels of outlet. Skill and experience in using these data, supplemented by facts on the purchasing power of the consumers, are essential in measuring the consumption per unit. There are indices of ability to buy for each important class of consumer, and these indicators may be verified with well-recognized broad business barometers. Long practice is required for accuracy, but experience repeatedly has shown that if painstaking work is done the errors can be confined to less than two percent.

The relation of the supply to the estimated demand shows in what direction the price will go. It will go up if the demand exceeds the supply and it will drop if gain in stocks persist. Current supply consists of the domestic production of crude oil and imports of crude and refined oils; and potential production depresses prices almost as does oil in tanks. Many companies depend upon transporting, refining, and marketing business for profits, and new

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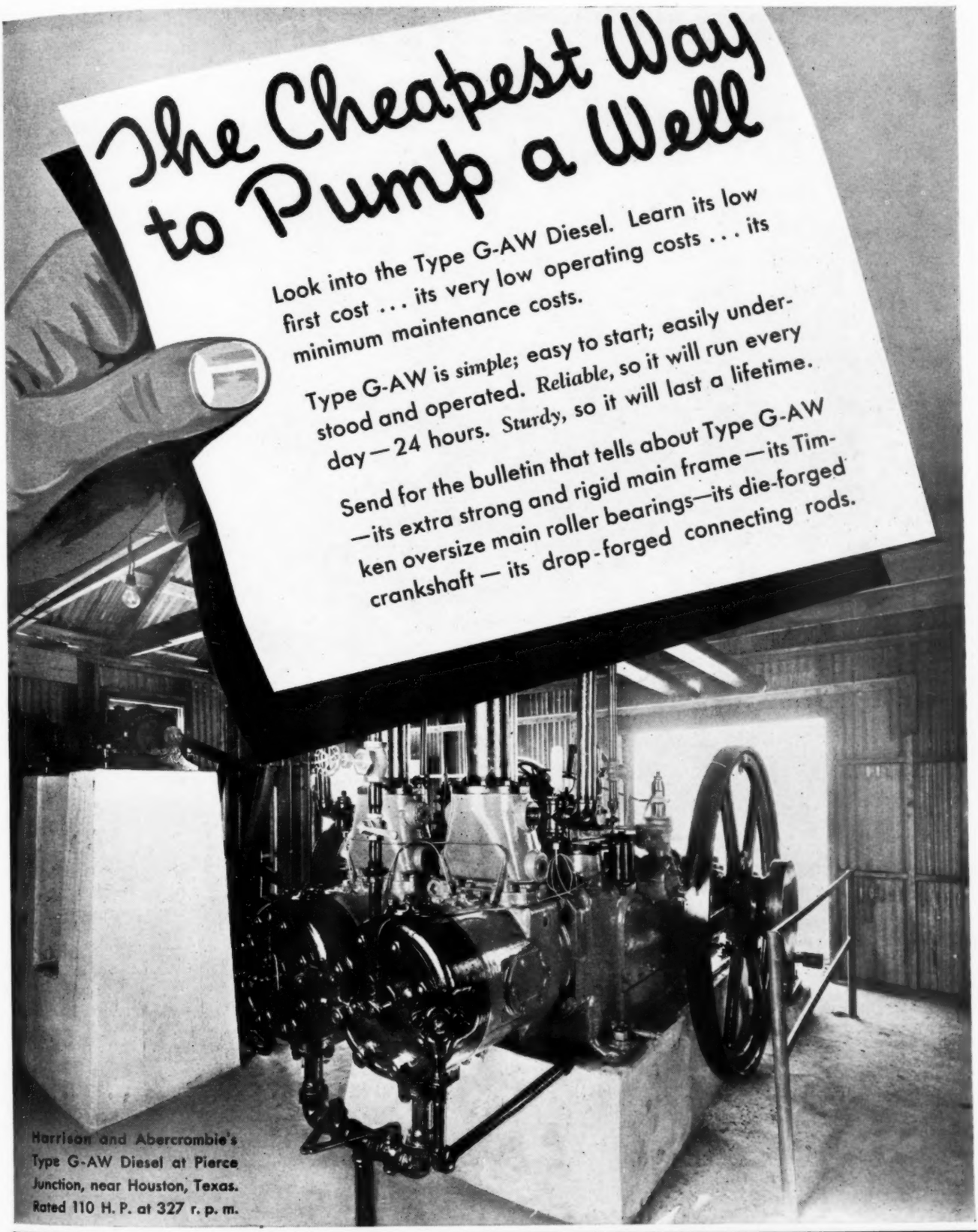

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money from outside the oil industry is constantly poured into production, and thus cost is a lesser factor than demand and supply in the price of crude petroleum.

Though more difficult to forecast than demand, the gross future supply, in areas not prorated, can be estimated for 90-day periods. If carefully made the errors in the estimates rarely exceed a few percent, and the trend of the total production can be determined for a longer period.

Space does not permit the detailed discussion of methods. As engineers and oil men know developed fields that have been defined drop at relatively slow uniform rates, permitting the use of projected decline curves. Where old pools are being worked over the estimator must possess full information with which to correct the decline curves. In the newer pools the production must be studied by wells or leases in great detail—locations, status of drilling, drilling rates, initials, potentials, pressures—and careful attention paid to the data and opinions of competent engineers and geologists familiar with the specific areas. Where and when proration is in effect the best estimates are, of course, the official allowables and estimates of the demand for the oils there produced.

The methods of studying prices for refined products are similar to those for crude prices except that refining output is an added factor and cost is a larger element. Refining and marketing are stable and conservative activities and public money is not attracted to them as it is by the high prize of success in production. In the long run prices must be high enough to make them profitable. Somewhere above or below the cost of making and selling refined products will fall the price, dictated by the supply and the effective public demand, and price in turn reacts on both the demand and supply. These economic G-men are the Triumvirate of the oil business, but unlike the famous dictators of ancient history, they are inseparable and their influence is universal.

Economics thus dovetails with engineering. A competent economist is a practical trained business man experienced in the use of demand, supply, cost, and price data, and the application of controlling business principles and practice. Figures and curves are his working tools and a full knowledge of what has happened in the past is an essential qualification. A good engineer has some knowledge of economics and appreciates its value. A thorough economist knows some engineering and recognizes its use. Each can help the other; and a good executive uses the knowledge and work of both. It is incumbent upon both engineer and economist to aid the oil man in solving the complex price problems that always beset him, and neither should be content until the executive acts upon his seasoned recommendations.

Taking Care of the Pennies

Fifteen years ago how many men did the oil companies use to look for leaks in operating departments? Thousands were at work to find and produce oil, and to move, refine, and dispense it to the public in the quantities desired. Yet were there not leaks in all such departments?

Oil was produced from leases where the pumping costs were higher than current prices or reasonable future price expectations, but the owners grimly held on in the hope that the "good old days" would return. Today these leases are being worked over or have been abandoned. In some instances by carefully studying the separate items that made up the lifting costs, engineers have found the weaknesses. With this information the reduced costs more than paid for needed betterments and saved the production. The way engineers have reduced underground losses by better well-spacing and improvements in the utilization of gas energy in the newer pools is too well known for comment.

In refining, the economic engineer is running races with the chemist. Chemical engineers are struggling to increase yields and improve the quality of products. Economic engineers are searching for fuel, treating, and overhead losses hidden in methods of operation. The manufacturing manager is utilizing the good ideas of both. Wastes in fuel, labor, and overhead expense due to variations in runs to stills, over-extended experimental work, and other unsound practices thus have been isolated and stopped. In one large Mid-Continent plant losses of from one to one and one-half million dollars on invested capital varying from five to ten million dollars over a five-year period thus have been converted into substantial profits.

The use of economic principles has not been confined to the saving of cents per bbl. in the production or fractions of pennies per gal. in the refining departments. Sounder business judgment has been put to work in executive control and a better balance is now maintained between the various divisions of many companies. Production programs, inventories, and cash position have been geared closer to markets and to the general economic pace of the country. It has been recognized that the oversupply and burdensome stocks from which the industry long has suffered have been due to unprofitable production in excess of market outlet, and failure properly to weigh costs and balance output with the changing conditions that have confronted the oil business. Inventories of refined oils and stocks of crude have been accorded their true place in the oil business. They are no longer regarded as speculative investments and are looked upon rather for assurance of an adequate supply to meet seasonal requirements or a decline in production.

Stabilizing Prices and Profits

In 1936 America consumed more oil than in any other year. No well-informed man denies the certainty of a further gain this year.

There is a little less oil in the ground, comparatively speaking, than there was a year ago. Oil should not be wasted. Surface stocks are substantially down. Fields are still prorated.

The shots of the geophysicist are heard again in some places and spinning again is the drill in the search for new pools.

Little or no profit in crude oil production can be made by many companies at present price levels.

Where now, oil men, and what will you do with the price?

When Edison said the ups and downs of industry would go on he stated a principle of economics as fundamental as what he knew of light and sound. No matter what the means employed, demand and supply can not be kept in perfect equilibrium. Prices must be raised to stimulate drilling and lowered to retard production. Closer attention than in past years should be given to the timing and amount of the price changes. A bird in the hand is important, but too high prices today might bring greater losses tomorrow. The interpretation of present conditions in terms of price is just as important as the anticipation of what is coming.

Overconsumption perhaps, and certainly oversupply, will come again. If stimulated by adequate prices and profits, the executives and their engineers and scientists will get America her needed oil.

Will management weigh economic conditions accurately, reduce the shocks of readjustment, and keep the producer out of the red?

Such are the writer's views of the uses and value of economic work in the oil business.

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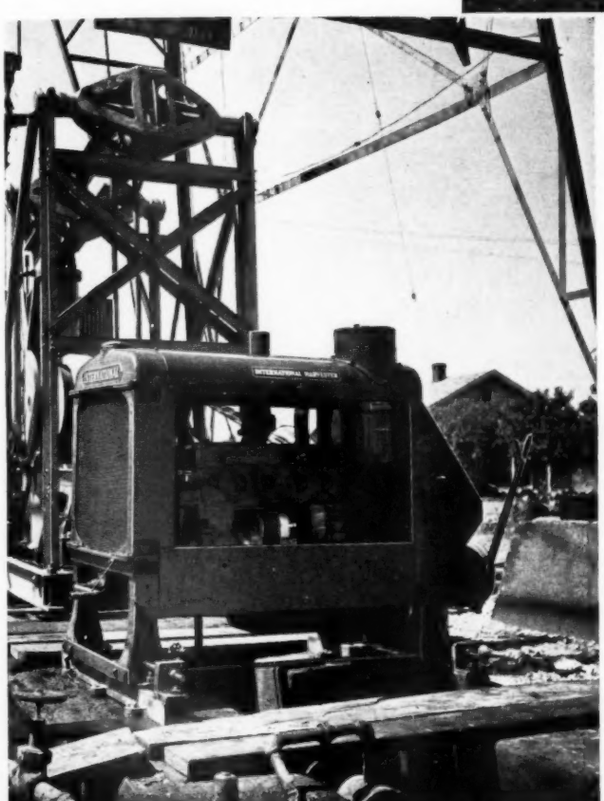

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Quantitative Determination of Adulteration of Lubricating Oils by Means of Identifiers • • Part 2

By S. FISCHER, JR.

IT will be noted, that the method of introducing the indicator and its extraction from the oils is defined within very narrow limits. It is this precise method of extraction that makes this indicator of value.

First, it was essential to know whether or not oil-soluble colors would affect the extraction of the phenolphthalein. A multitude of such colors were investigated and none of them showed any interference. Three oil-soluble reds, two scarlets, one orange, one yellow, two browns, four blues, three greens, and one violet comprised the color scale tested. The amount of color used was always approximately 60 times that of the phenolphthalein. Most of the common and even the rarer indicators were tried for interference, but none showed any effect upon the determination of the phenolphthalein. The reason for the lack of interference of the indicators as a whole is due to the fact that but few are soluble in oil in their entirety and if this is not the case the indicator is useless for the identification of adulterants quantitatively. Positive reproductability is imperative for all quantitative work of this type. Another item that entered into the consideration was, that while some indicators dissolved satisfactorily, their sensitivity was outside the scope of practice.

Toward sunlight and straight ultra-violet rays in 4-oz. bottles the identifier is immune. For example, a refinery-treated sample was subjected to direct sunlight for 17 days. The results obtained are shown in Table 2.

TABLE NO. 2

Showing Stability of Phenolphthalein Toward Sunlight

Nessler Tube Readings in cm.		Percent F. in R. T. O. Exposed to Sun
Standard R. T. O. 100%	R. T. O. Exposed to Sun for 17 Days	
3.70	3.75	98.67
6.20	6.25	99.20
8.70	8.85	98.31
		Av. 98.73

ABBREVIATIONS:
R. T. O.—Refinery Oil Treated with Phenolphthalein-Hexalin Identifier.
F.—Phenolphthalein.

Considering the accuracy of the method of color testing it is obvious that there is no change in the phenolphthalein identifier due to the sunlight.

A refinery sample subjected to the effects of direct ultra-violet rays in an ordinary 4-oz. bottle over a period of one week showed no decomposition of the phenolphthalein, the colorimetric test showing 100 percent of phenolphthalein present.

Heat has no effect upon the phenolphthalein below approximately 527 deg. fahrenheit. The curve in Fig. 1 may prove of interest. It is apparent that even after 527 deg. fahr. the decomposition of the phenolphthalein progresses only slowly.

The cost of the identifier per gal. of oil treated is $0.000116. This figure holds true for the time at which the report was delivered to the firm for whom the work was done, namely, December 5, 1932; however, the cost at present would vary little from the figures given at that time, due to the fact that the cost per lb. of phenolphthalein and of hexalin varies within very narrow margins. At the time mentioned the costs were based on the following figures:

Phenolphthalein: U. S. P. in 200-lb. lots.....$0.90 per lb.
Hexalin: in 50-gal. drums 0.40 per lb.

Both products were guaranteed to be of uniform composition, which item, of course, is essential for the success of the identifier.

Finally the question had to be answered, whether or not phenolphthalein was used in the production of lubricants. This could be very definitely answered by no! Phenolphthalein is used solely in the laboratory as an indicator in analytical work. In the plant production of lubricating oils it is never used.

Oil Brown M. This color was chosen as an oil indicator due to the fact that it was not a stearin base dye. This is guaranteed by the manufacturer of Oil Brown M. The dye is essentially employed in the varnish industry, and not in the lubricating oil industry. It is soluble in lubricating oils with difficulty and, therefore, an insufficient amount would enter the oils directly without some carrier. Finally, its peculiar reddish color under certain conditions of extraction makes Oil Brown M a valuable asset for identification of adulterants in lubricating oils.

Preparation of the Identifier Stock Paste: The task of getting the same amounts of Oil Brown M into lubricating oil stocks presented one of the most difficult problems in the total investigation. No solvent investigated acted satisfactorily as a carrier for the dye. Finally it was found that lubricating oil itself served as carrier, provided the dye was finely enough divided.

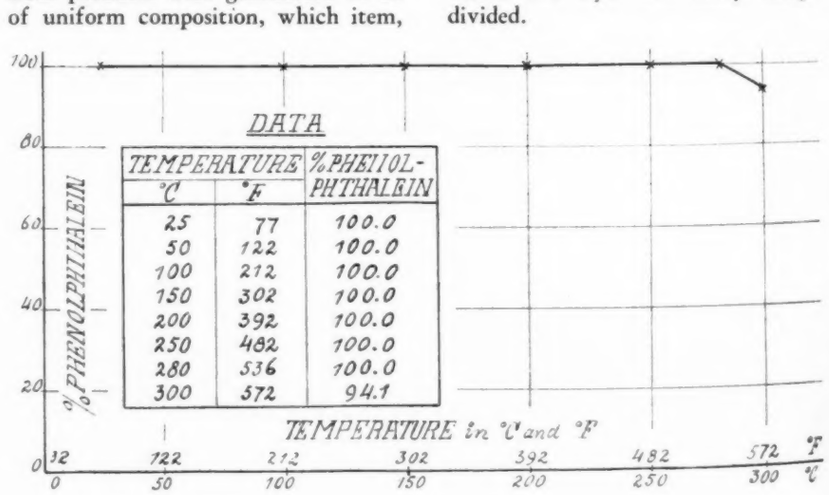

Fig. 1. Deterioration curve for phenolphthalein in plant treated oil

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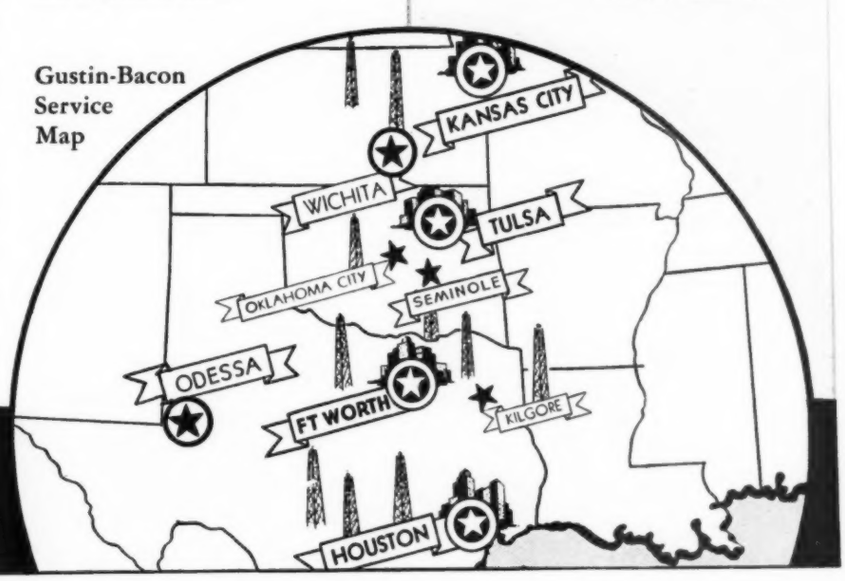
Gustin-Bacon Service Map



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The identifier stock paste was prepared in the following manner: Mix thoroughly, in a double-jacketed, steam-heated paint mill, 25 lb. of Oil Brown M with 25 lb. of lubricating oil. Heat this mixture to 212 deg. fahr. and grind until absolutely smooth. The time required to prepare a batch of this size is approximately 30 minutes. When finished, store in metal cans and seal tightly until ready for use. The final material is in the form of a paste of extremely fine structure as far as the dye particles are concerned.

Treatment of a 2000-Gal. Batch of Oil for Market: Introduce 2000 gal. of the oil to be treated in a suitable blender. Heat the oil to 150 deg. fahrenheit. Meanwhile weigh out carefully 320 gm. of the Oil Brown M stock paste into a container and heat this to 212 deg. fahrenheit. When the oil in the blender has reached 150 deg. fahr. agitate the oil thoroughly and introduce the hot Oil Brown M stock, taking care that all this stock enters the oil. This latter may be accomplished readily by washing the receptacle holding the stock with oil in the blender and finally swabbing out the container with a brush and washing the brush out in the mass of oil.

Heating of the Oil Brown M paste is best done by placing the container holding the stock in a water bath. Direct contact of the paste with a flame or an electric heater is dangerous, since some of the Oil Brown M might decompose under such conditions.

To begin plant production of such indentifiable oils requires, as already mentioned, treatment of stocks in the field such as filling stations, storage tanks, etc. It is difficult to heat identifier stocks in the field and they should be applicable in the cold state.

As for the phenolphthalein-hexalin identifier stock, a method to service field tanks and residual oils in filling stations was developed. A specific case will make this matter clear.

Assume a tank at a filling station still holds ten gal. of the original plant oil, not treated for identification. This 10-gal. lot must be either discarded, sent back to the plant for treatment, or must be capable of being treated with the identifier in the tank. Discarding this volume of oil would mean a loss to the oil station. Having to return such small amounts to the plant for treatment would mean an added expense for the refinery; therefore, the only feasible solution of the problem was to determine a method for cold-treating with the identifier stock.

Returning to the 10-gal. lot of untreated oil: At the refinery laboratories, weigh out 1.6 gm. of the Oil Brown M paste. Into this stir one cc. of c.p. benzol. Heat 100 cc. of the oil found in the tank at the service station to 150 deg. fahrenheit. The requisite amounts needed for this purpose should be taken at the time that the gallonage is obtained. Cool and place in well-sealed metal containers. These containers are then taken to the tank to be treated—added to the stock contained therein under active agitation either with paddle or compressed air, care being taken to rinse carefully the container holding treatment stock until assured of complete introduction of the stock in the oil. To stocks, so treated, plant-treated oil may then be added without fear of dilution.

Identification Test. Preparation of Test Solution: Dissolve 16 gm. of potassium hydroxide in 60 cc. of distilled water. When completely dissolved make up to 100 cc. with more distilled water. To this add 100 cc. of c.p. methyl alcohol and shake. Allow to stand overnight and filter. Keep this solution in rubber-stoppered bottles.

Obtaining the Test Color: Place 15 cc. of the refinery-tested oil in a separatory funnel. Add 15 cc. of ether and mix. To the mixture add 40 cc. of the test solution and shake for ten minutes. Allow to settle; or better, centrifuge. Two clear layers will be obtained. The upper layer will be the oil-ether mixture, while the bottom layer of liquid will be the test solution containing the identifier, which imparts to the test solution a peculiar, typical red color. The testing is similar to that of the phenolphthalein-hexalin identifier, with modifications as mentioned above. In this manner over 100 samples were tested with this identifier and the total deviation from the correct results was 1.867 percent. The maximum deviation allowable, according to the company for whom this work was done, was ten percent. This high allowance of deviation was never reached, all results being usually far below this.

Typical tests are given in Table 3. The samples herein were submitted to the writer by the firm for whom this work was done, and their values will be taken as 100 percent. The results returned to the company are those in column 2.

With the exception of sample No. 5, all checked with the figures of the submitted samples. The deviation in No. 5 may be attributed to eye strain. Each sample was tested ten times and the averages of the ten readings taken as the final result. In all, therefore, 60 readings were taken and it is astonishing that no greater differences were found than that in sample No. 5.

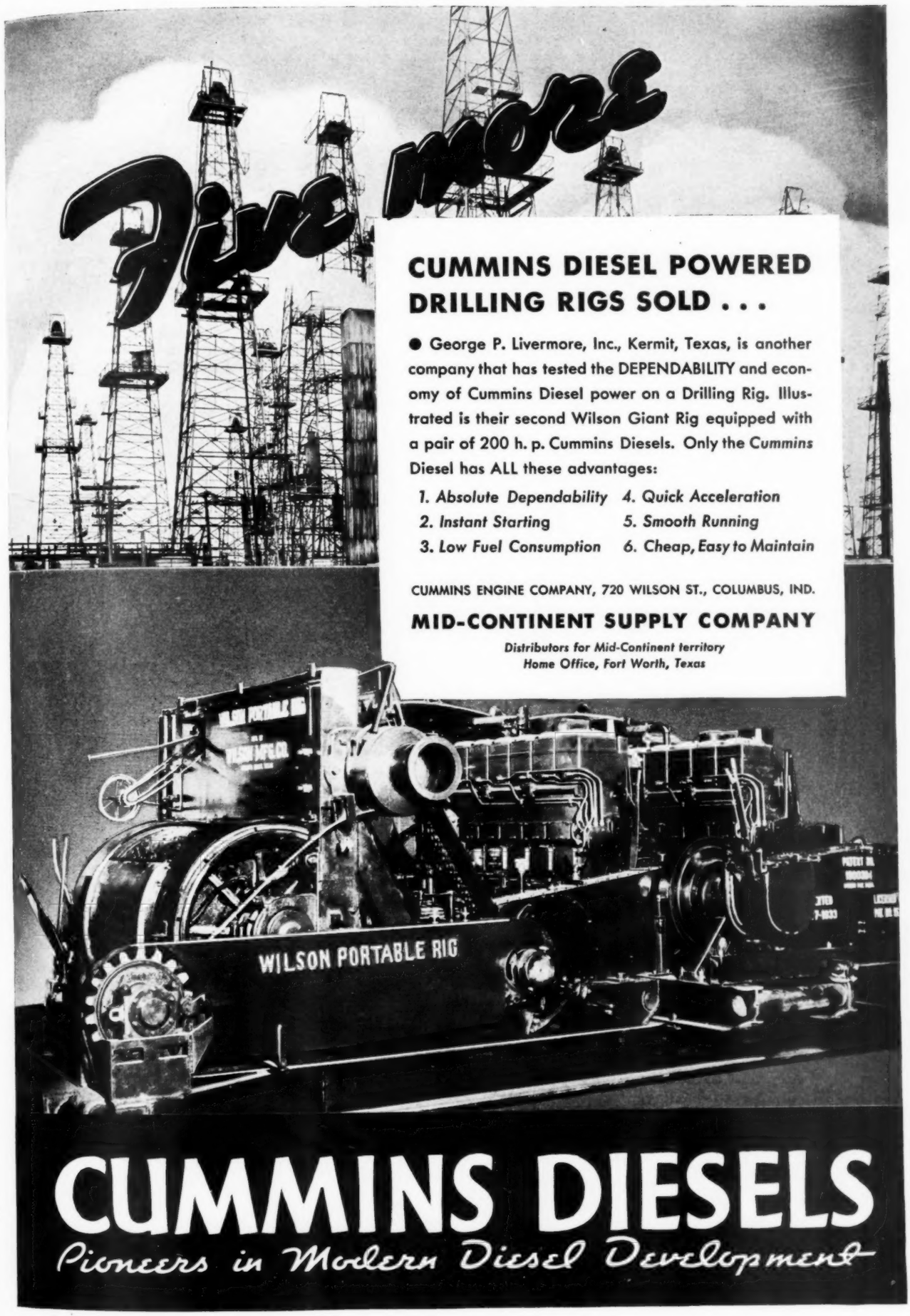
As to the care taken in making the extractions, filtrations, etc., the same precautions have to be observed as when working with the phenolphthalein-hexalin indicator; also, if the dilutions with other oils are very great, it is advisable to use larger oil samples for test, the same precautions being taken as those recommended under phenolphthalein.

TABLE NO. 3

Results Obtained by Use of Oil Brown M. Identifier

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample No.	Percent R.T.O.	Percent A.O.	Height in Nessler Tubes			Percent of R. T. O. Det.			Average Percent of R. T. O. Determined	Approximate Percent of R. T. O. Determined	Approximate Percent of A. O. 100—Col. II	Approximate Percent Error	Actual Percent Error R.T.O Col. 2 and Col. 10
			No. of Test Runs Made			No. of Test Runs							
			I	II	III	I	II	III					
Standard	100	0	1.500	2.125	1.000	100.0	100.0	100.0	100.0	100.0	0	0	0
1	70	30	2.125	3.05	1.470	70.6	69.7	68.0	69.4	70.0	30	0	—0.6
2	90	10	1.650	2.375	1.125	90.9	89.5	88.9	89.8	90.0	10	0	—0.2
3	40	60	3.625	5.375	2.125	41.3	39.5	47.1	42.6	40.0	60	0	+2.6
4	60	40	2.500	3.500	1.700	60.0	60.7	58.8	59.8	60.0	40	0	—0.2
5	80	20	2.205	2.775	1.325	74.7	76.6	75.5	75.6	75.0	25	5	—4.6
6	50	50	3.025	4.275	1.950	49.6	49.7	51.3	50.2	50.0	50	0	+0.2

ABBREVIATIONS:
R. T. O.—Refinery: Oil Brown M Identifier.
A. O.—Oil Used for Adulteration.



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Regarding the effect of the Oil Brown M on the properties of the oil treated, it was found by the laboratory of the company for whom the work was done that they were negligible. The only effect produced was the increase in the intensity of the color of the oil by one-fourth of one unit.

The sensitivity in terms of the treatment submitted to the company is 0.08 gm. of Oil Brown M per gal. of oil—that is, in 3785.33 cc.; therefore one cc. of the oil will contain 0.000021 gm. of Oil Brown M, or one part by weight of Oil Brown M to 47062 parts by volume of the oil. The volume of Oil Brown M to be added to the oil may be reduced in the same manner as the phenolphthalein. Smaller volumes of Oil Brown M paste may be added and larger volumes of oil used for the identification test.

The value of the Oil Brown M lies in the fact that the name itself is utterly misleading. It imparts to oils a peculiar red color. The complexity of the compound yielding the typical red color with certain reagents is unique. The difficulty of introducing the dye into lubricating oils and the complexity of the extraction solution enhances the value of the substance for identification purposes.

The same series of tests for the interference of oil-soluble dyes and indicators were run on this identifier as given under phenolphthalein. No interference was observed.

Under heat, the Oil Brown M stands up, decomposing at 392 deg. fahrenheit. The rate of decomposition above this temperature is faster than that of phenolphthalein after it has reached its decomposition temperature, as may be seen from the curve in Fig. 2.

Visible rays of light, such as the rays in sun light, cause the dye to decay. In other words, oils treated with Oil Brown M could not be kept in glass containers over a period of time without losing their identification value. In metal containers, however, the life of the identifier is unlimited.

The laboratories of the company for whom this work has been done informed the writer, that upon subjecting oils treated for identification with Oil Brown M to ultra violet rays directly in 4-oz. sample bottles, decay took place to a degree, due rather to the visible rays in the ultra-violet light than to the effect of the ultra-violet rays themselves.

Finally, a quantitative field test was worked out for this identifier: Place a five cc. sample of the regular refinery stock treated for identification in a small separatory funnel. Extract with five cc. of acetone for five minutes. Allow to settle. The acetone extraction liquor will float on top and the oil below. The acetone extract will have a typical brownish color, which serves as the 100 percent value for color comparison. Treat a sample under suspicion in like manner and compare with standard, colormetrically. To eliminate the trouble of making a standard test for every sample to be tested for adulteration, the writer suggested making a colormetric scale in the laboratories with samples of known composition, ranging in steps of 5 percent from zero adulteration to 100 percent adulteration. Against this scale adulterated samples in the field then could be preliminarily tested by the field men. After this test, if a sample is under suspicion it then can be sent to the company's laboratory for final testing.

The Oil Brown M may be obtained of constant purity at the following prices: in 1-lb. lots the price is $2.45; in 25-lb. batches the price is $2.05 per lb., and in lots of 100 lb. the price quoted is from 10 to 15 cents less per lb. than that quoted for the 25-lb. batch. The cost of treating one gal. of oil is $0.0003616.

Methyl Red. In order to cover up the phenolphthalein color reaction, an indicator was sought whose acid reaction would give approximately the same tint as does the phenolphthalein in an alkaline solution. The indicator found most promising was Methyl Red.

Preparation of Stock Solution: This solution has to be prepared each time a batch is to be made. It cannot be stored, because its concentration might change as a result of evaporation of the pyridin.

Dissolve 11.2 gm. Methyl Red in 111 gm. of pyridin just prior to treating a 2000-gal. batch of oil.

Treating a 2000-Gal. Batch of Oil: 2000 gal. of oil are placed into a suitable blender. Agitate the oil thoroughly and heat to 120 deg. fahrenheit. At this point introduce the Methyl Red-Pyridin stock solution, prepared as above mentioned. Keep agitating and allow the temperature to rise to 150 deg. fahrenheit. This rise in temperature from 120 deg. fahr. to 150 deg. fahr. should require 30 minutes. Fill oil in drums ready for market. Precautions are to be taken to assure oneself of the complete entry of the Methyl Red-Pyridin stock by rinsing the container of the identifier solution thoroughly with oil in the blender and finally swabbing the container with a brush and rinsing the brush in the bulk oil in the blender.

Several methods of making larger batches of identifier solution have been tried. One might compensate with fresh pyridin for any evaporation losses. This would add to the cost of the process, due to the cumulative effect of the pyridin losses. Another method tried was to make up ten cc. of identifier stock solution in excess of that required for the 2000 gal. and allow an equivalent number of cc. obtained by dissolving the 11.2 gm. of Methyl Red in 111 gm. of pyridin, to enter the oil. Considering all factors, the best method of procedure appeared to be the one first mentioned.

Identification Test: Test solution. Mix 500 cc. of c.p. concentrated hydrochloric acid (37 percent gaseous HCl) with 500 cc. of distilled water. Allow to cool and make up with additional distilled water to exactly 1000 cc. Store in glass stoppered bottle.

Obtaining the Test Color: Place 15 cc. of Methyl-Red treated oil in a separatory funnel. Add 15 cc. of ether and shake. To this add 15 cc. of test solution and shake well for ten minutes and then centrifuge or allow to settle. Two layers appear; the oil-ether layer on top and the test solution containing the indicator at the bottom. This bottom layer will have a reddish-pink color.

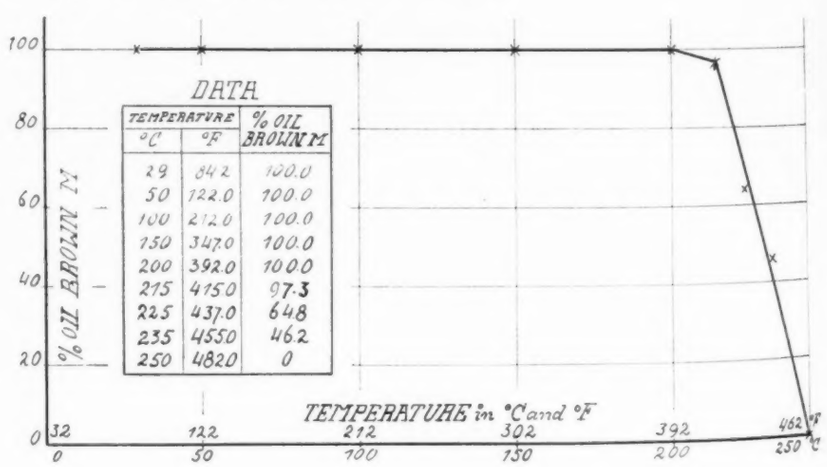

Fig. 2. Deterioration curve for Oil Brown M plant treated oil

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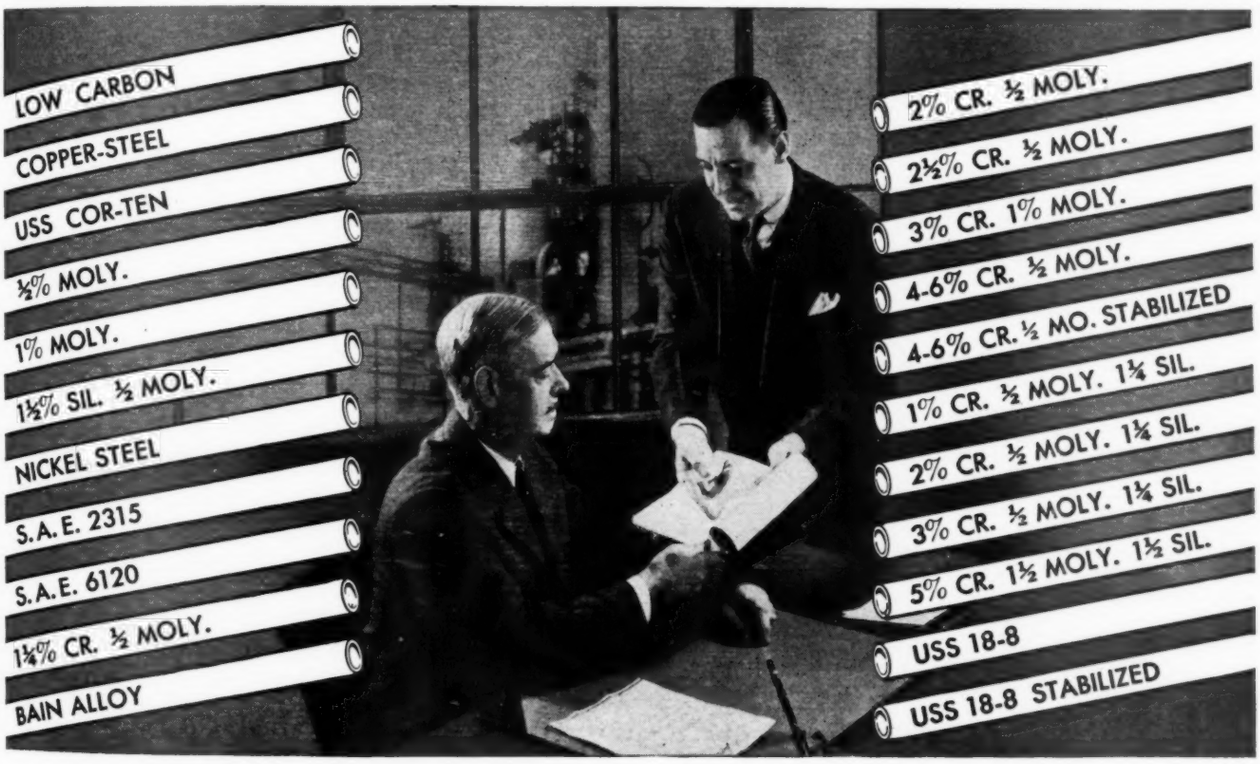

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Test for Adulteration: Take two separatory funnels and place in one 15 cc. of refinery identifier oil, and in the other 15 cc. of the assumed adulterated oil. To each funnel add 15 cc. of ether. Shake to mix. Add 15 cc. of test solution to each funnel and shake for ten minutes. Allow to settle or centrifuge. When both layers are clear, draw off the bottom red layers containing the identifier. Wash each oil-ether liquor left in the funnels three times with 15 cc. of distilled water, shaking each wash for five minutes, and test for absence of acid with litmus. When no more acid reaction is present the washing is sufficient. Usually two washings are sufficient. These two washings are added to the respective original acid extractions and these are then made up to equal volumes with test solution and are ready for the colorimetric determination.

Table 4 gives some examples. The sensitivity of Methyl Red is as follows: per gal. of oil, 0.0056 gm. of Methyl Red are used. This divided by 3785.33 gives 0.0000015 gm. of Methyl Red per cubic centimeter of oil. Therefore the sensitivity of the indicator is one part of indicator by weight to 666667 parts of oil by volume.

So far as the usefulness of the indicator is concerned heat has no effect. The melting point of Methyl Red lies between 181 deg. cent. and 182 deg. cent. (357.8 deg. fahr. and 359.6 deg. fahr.). Here the temperature of decomposition is higher than the melting point.

A Methyl Red treated oil must be kept in metal containers in order to maintain its identification value, as direct sunlight over a comparatively short period of time will make this substance useless for the purpose of identification.

While the process of identification is comparatively simple, the method of introducing the Methyl Red into the oil by means of pyridin is unique. The field test for this identifier, as may be seen from the extraction solution, is extremely simple and due to the ease of identification the methyl red is not recommended as a satisfactory identifying agent for lubricating oils, if used alone. Its essential value is as a camouflaging agent, which topic will be treated in detail later.

Methyl Red may be obtained in pure form on the market in any amounts. While the cost *per se* appears high, the small amounts used for treatment make the initial cost negligible. The prices quoted for Methyl Red are: in 5-lb. lots, $10.00 per lb.; in 25-lb. lots, $9.50 per lb. and in 100-lb. lots the cost drops to $8.50 per pound. The price of pyridin f.o.b. Rahway, N. J., as quoted is: $0.95 per lb. in 56-lb. tins. The cost of treating one gal. of oil is $0.0002208.

(EDITOR'S NOTE: Part 3 of this article will appear in the March issue.)

TABLE NO. 4

Results Obtained by the Use of Methyl Red-Pyridin Identifier

1	2	3	4	5	6	7	8	9	10	11	12
Sample No.	Prepared Samples		Nessler Tube Readings in cc.			Percent of R. T. O. Determined	Average Percent R. T. O. Percent Determined	Approximate Percent R. T. O.	Approximate Adulteration Determined	Approximate Percent Error	Actual Percent Error R.T.O. Col. 2 and Col. 8
	Percent R. T. O.	Percent A. O.	No. of Readings	Standard	Sample						
I	40	60	1	4.35	11.35	38.3	38.3	40	60	0	—1.7
II	80	20	1 2	3.45 3.10	4.20 4.03	82.1 76.9	79.5	80	20	0	—0.5
III	90	10	1 2 3 4	2.50 2.50 4.95 5.00	3.00 2.80 5.15 5.80	83.3 89.3 96.1 86.2	88.3	90	10	0	—1.7
IV	10	90	1 2	0.90 1.23	6.95 11.40	12.9 10.8	11.9	10	90	0	+1.9

ABBREVIATIONS:
R. T. O.—Refinery Oil Treated with Methyl Red-Pyridin Identifier.
A. O.—Oil Used for Adulteration.
Col.—Column.

Flamenol—a New Plastic Material

CHEMISTS and insulation engineers for several years have watched the development of flexible synthetic plastic materials such as cellulose acetate, Glyptal, Duprene, and Thiokol. Flamenol is a newcomer in this field and, although in its present form it has been known for only a relatively short time, strides have been made in its development and application that are worthy of note, says John Liston, of the General Electric Company, in making his annual review of the electrical industry.

Rubber-like in many respects, Flamenol can be made very soft and flexible, or with a celluloid-like rigidity. It can be put into solution for coating and impregnating, and can be compounded, filled, calendered, extruded, and moulded in much the same fashion as rubber, but there are many properties differing from those of rubber that make Flamenol outstanding as an electrical insulating and cable-jacketing medium. It is extremely water-, acid-, alkali-, and oil-resistant. It is tenacious, has good textile strength, and its dielectric strength is good in comparison with that of the best grades of rubber. Flamenol compound does not support combustion, hence cable can be made flameproof in the true sense of the word. Its life is excellent as it does not oxidize even in the presence of ozone, and it is, therefore, unaffected by corona discharges.

Cables jacketed with Flamenol compound have been buried in the soil over an extended period of time, being subjected to severe winters and spring floods. Tests on these retrieved cables showed them to be in as good condition in every respect as the day they were buried.

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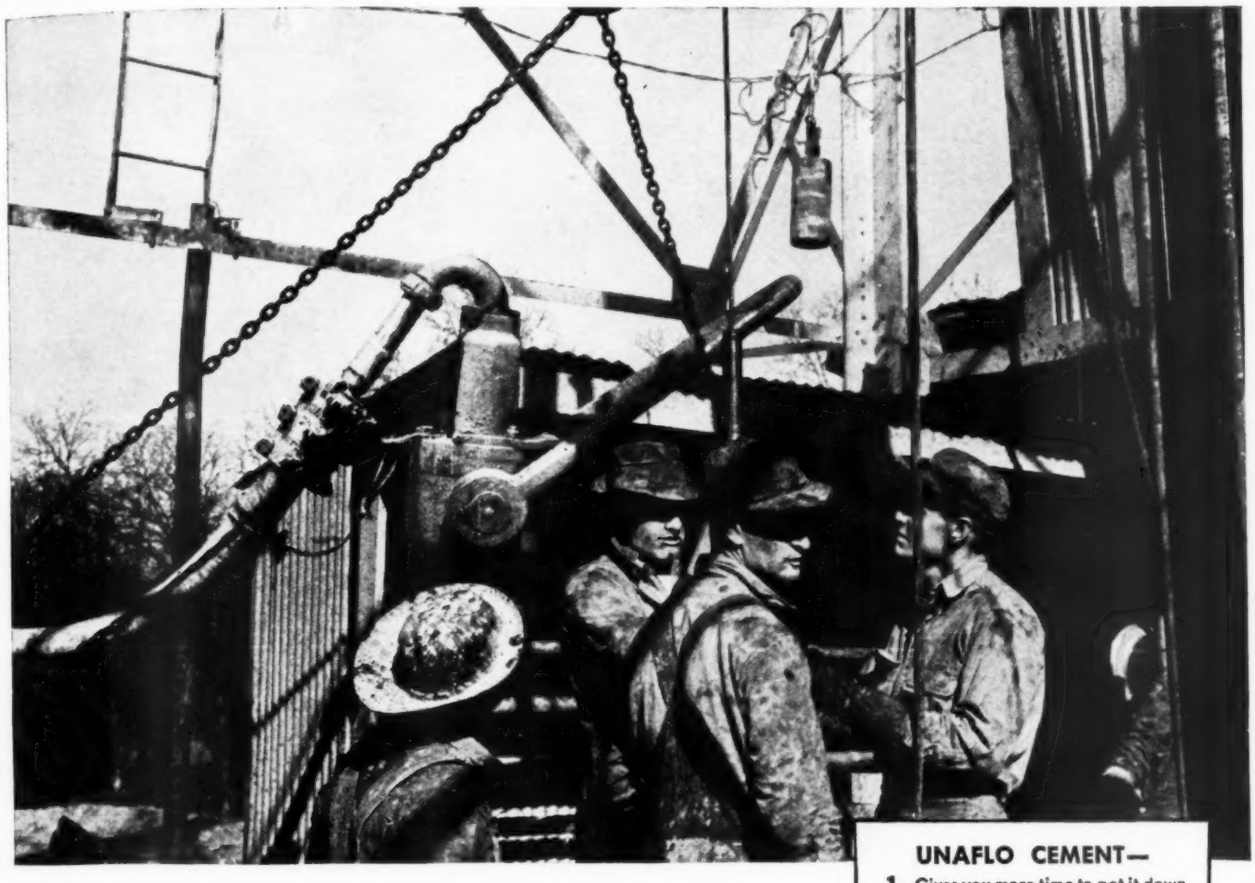

● Here is how Unaflo performed on a plug-back job recently reported from the field:

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2. Remains fluid longer.
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9. Requires no ice.
10. Makes squeeze and plug-back jobs easier, surer and more successful.

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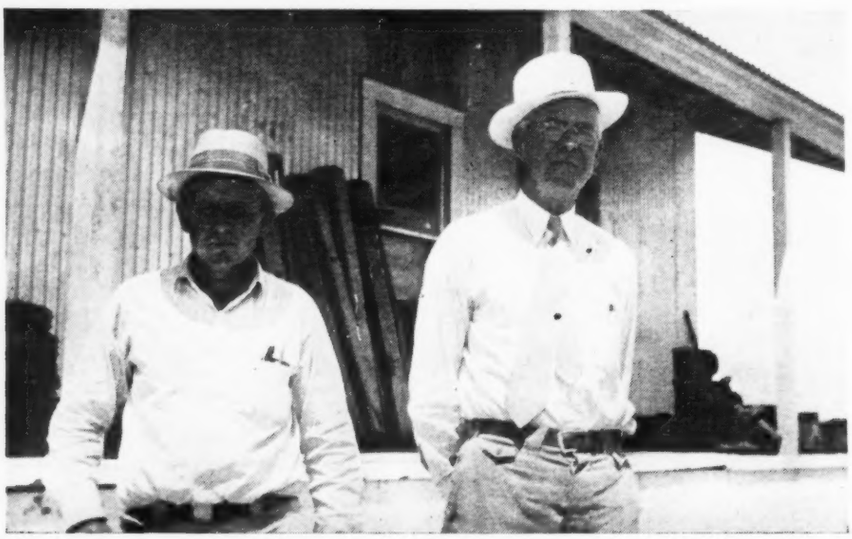
International Petroleum Corporation's holdings near Borger, Texas, example of a modernly-equipped and efficiently-operated property

Modern Lease Equipped for Economical Operation » »

Camp cottages are all of a different architectural design

Lease tanks are of wood



W. E. Fussell (left), superintendent, and Geo. K. Taggart, general manager, of International Petroleum Corporation

A PRODUCING lease of interest because of its neatness, up-to-date equipment, and the manner in which it is operated is that of the International Petroleum Corporation near Borger, Texas. The wells are pumped electrically and power to operate the motors, as well as for supplying other electrical requirements of the lease, is provided by two 156-kva. generators powered by two 160-hp. twin gas engines. The power is transmitted from the engine to generator through a 14-string V-flat belt drive. The belts run from the flat face of flywheel on engine to grooved pulley on generator.

The transmission system is composed of four circuits in sets of two each. Each set has its two circuits connected at the farthest point from the plant through a sectionalizing switch. This allows production to be maintained from a majority of wells even though an interruption should occur due to a break in one or two circuits. The board wiring is such that either generator may be connected with either one or all four circuits.

Each well is equipped with a 15-hp. splash-proof induction motor connected to the reduction gear by a V-belt drive. The double-reduction geared unit has a gear ratio of 26.95 to 1 and the V-belt drive from motor to unit a

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Jess Simpson (left), assistant superintendent, and C. A. Bennett, field foreman

ratio of 3.1 to 1. This gives an overall reduction ratio of about 83.5 to 1, or with motor running at 1160 r.p.m. the well is pumped at about 14 s.p.m.

A 10-in. by 4½-in. duplex power pump driven by a 40-hp. squirrel cage motor is employed as a pipe line pump to handle the production from three tank batteries. A 45-ft. A-mast made of 8-in. pipe is provided at each well for cleaning-out and repair work, and when the drilling program is completed, there will not be a derrick on the lease.

A portable pulling machine mounted on a truck is employed for working over the wells, which are approximately 3000 ft. in depth. Production is from dolomitic lime.

Redwood tanks are used to receive the crude oil from the wells. Each battery contains two or three 500-bbl. tanks.

A departure was made in the construction of company cottages, each house being of different design, as shown in an accompanying illustration.

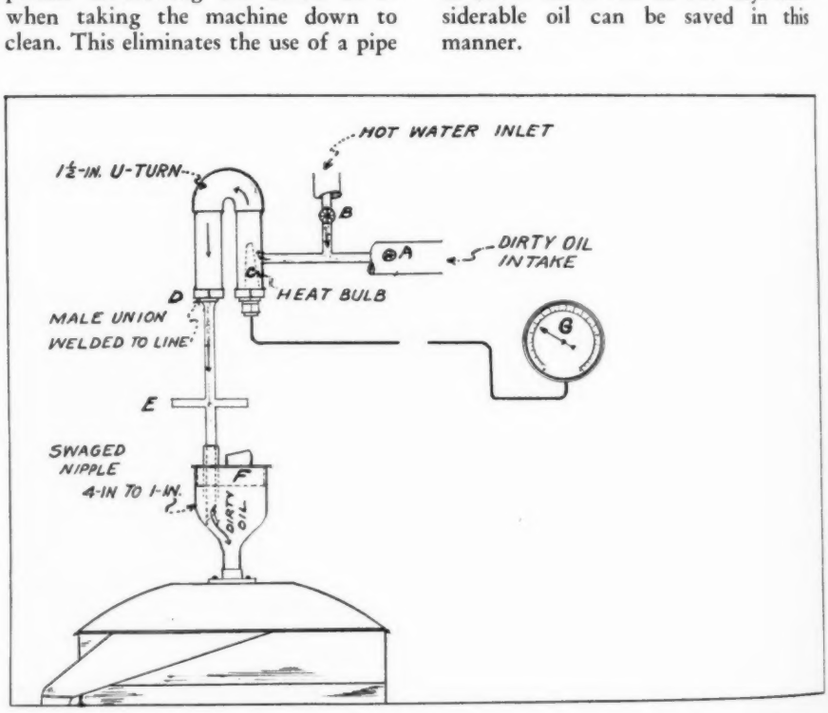
The company also has a large warehouse, garage, and repair shop. These buildings, together with the office and cottages, are all enclosed by a heavy, woven wire fence.

Correct Temperature for the Oil Centrifuge » » »

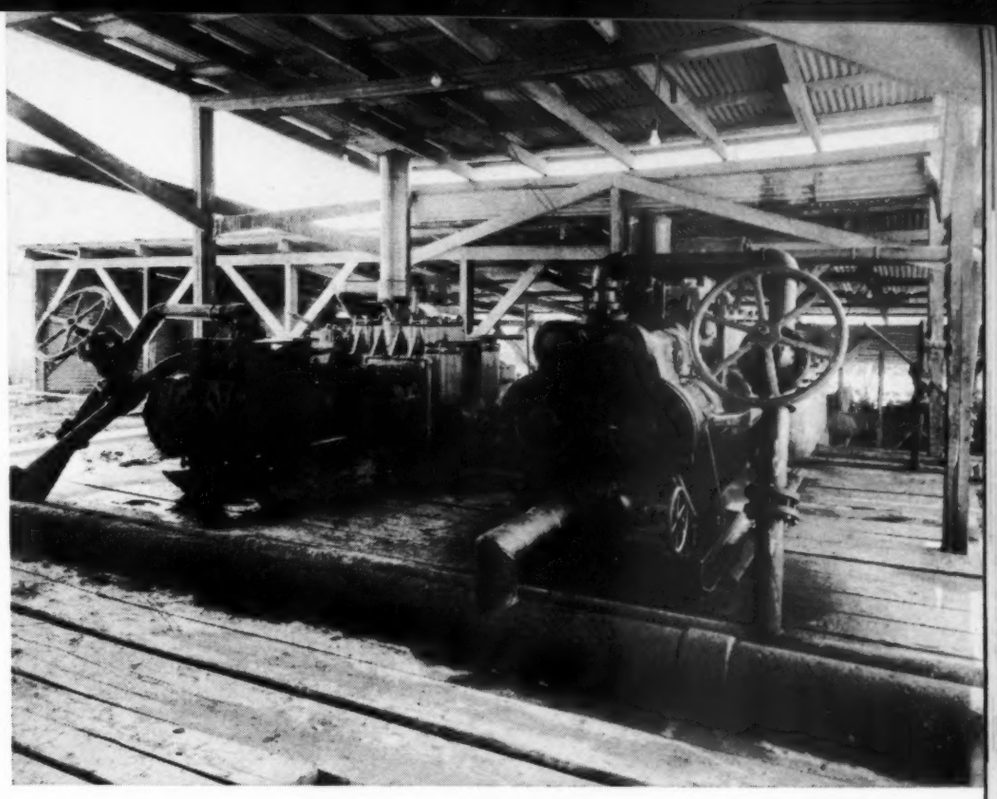
By JOS. L. INGRAM

CONSIDERABLE difference of opinion exists among the engine room force regarding the proper method of operating an oil centrifuge. Every engine room, or plant, has different characteristics demanding suitable temperatures and different methods of handling the purifier. For instance, not long ago in submarine service it was discovered that the presence of small quantities of iron oxide (ordinary rust) in the oil made it extremely hard to break down an emulsion and settle out the water; so every precaution was taken to prevent the lubricating oil from becoming contaminated with rust. In another instance known to the writer, the engineer centrifuges his fuel oil cold, taking as much wax out as possible, although his predecessor centrifuged his oil hot and with a little additional cleaning of the injection system burned it in the engine quite satisfactorily.

Regardless of plant characteristics, proper handling and correct temperature readings of the oils being cleaned are requisite. A very neat hook-up to the centrifuge, and one that proves efficient, can be made as shown in the accompanying drawing. With the thermometer bulb submerged in the incoming oil at all times, the correct temperature is shown on gauge *C*. Valve *A* regulates the flow of the dirty oil into the machine. Valve *B* is used to run hot water in with the oil being cleaned if desired. If not desired it is quite handy for floating out the oil before cleaning the bowl and discs, then filling to make the water seal before starting up again. The two handles welded to the ½-in. feed line at *E* permit unscrewing the union at *D* when taking the machine down to clean. This eliminates the use of a pipe wrench and thus prevents unsightly wear on the fittings. By offsetting the intake pipe in the cover at *F*, it can be raised at any time and small quantities of dirty oil picked up by hand poured into the machine for cleaning instead of down the sewer. In 365 days considerable oil can be saved in this manner.



Compact centrifuge hook-up for obtaining correct temperature reading. Vibration is taken care of and hook-up is easy to dismantle



Mud pumps used in drilling No. 1 Hebert were of the latest design

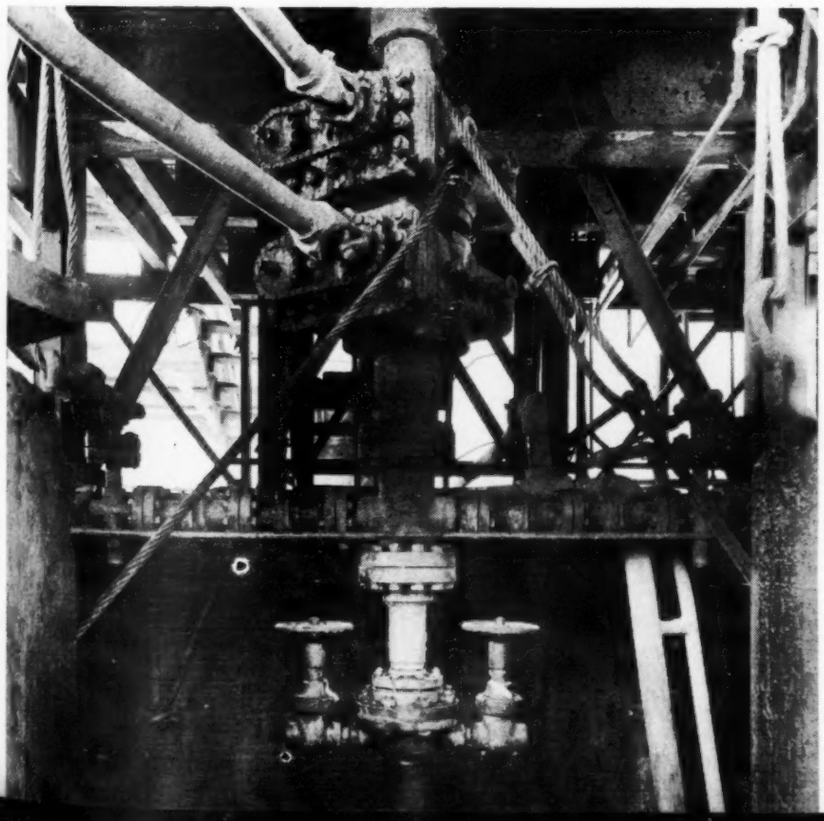
By

K. C. SCLATER

Well 12,216 Feet Deep Offers Difficulties in Completion

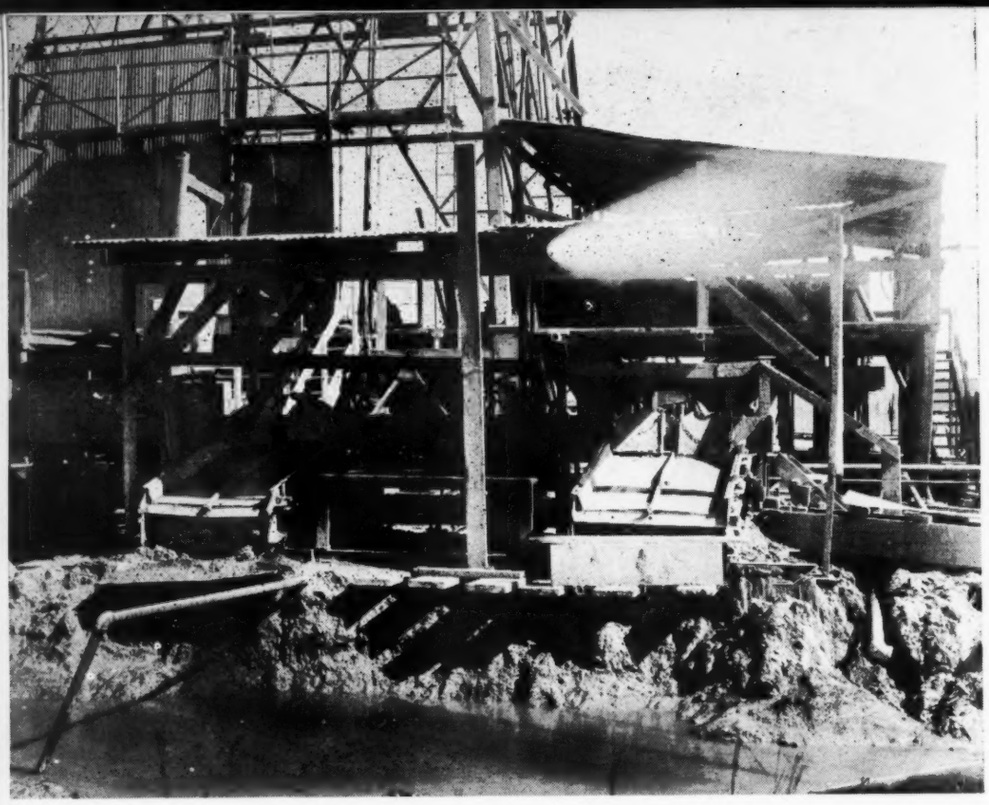
Wildcat in Southern Louisiana, at present the second deepest hole ever drilled, has struck high gas pressure, making safe completion a problem

A FORMIDABLE task confronts the Continental Oil Company in successfully completing a deep prospect well that has every indication of being commercially productive. This well, the Ophe Hebert No. 1, near Abbeville, Vermillion Parish, on the Louisiana Gulf Coast, is 12,216 deep. On several occasions it has threatened to blow out and this is adding to the difficulties of making a proper completion at this great depth. High gas pressure has been encountered, so the company has been compelled to proceed with the greatest caution in an effort to forestall any unruly tactics, to which deep wells on the Gulf Coast are so prone.



Casinghead connections and blow-out preventer used in drilling operations on the well

Interest attaches to this well because of its depth. It is the second deepest hole ever drilled and at its present depth is only 552 ft. short of the depth reached by the Gulf McElroy, No. 103, which, abandoned at a depth of 12,768 ft., holds the world's record of the deepest hole ever drilled. Should the Ophe Hebert No. 1 be completed as a producer at its present depth, it will hold the record of being the deepest producing well in the world, bringing back to Louisiana a record it held last month for the short space of ten days. The honor of being the deepest producer is a fleeting one these times. It was acquired by Louisi-



A view of the well showing the two mud screens, driven by a single motor

ana on January 7, 1937, when The Texas Company's well, Rigolettes Fur Co. No. 5, was completed as a producer at 10,244 ft. in the Lafitte field. Ten days later, on January 17, 1937, the honor was wrested from Louisiana by the Tide Water Associated Oil Company, Associated Division's well McGonigle No. 12 in the Ventura Avenue field, California, which was brought in as a producer, flowing naturally, at a depth of 10,569 ft. (see article on p. 86 of this issue.)

The casing in the well consists of 250 ft. of 18⅝-in. conductor; a string of 13⅜-in. casing set at 1881 ft.; a string of 7-in. 30-lb. seamless set at 10,960 ft. and cemented with 2000 sacks of cement; and a string of 5-in. O.D. flush-joint seamless casing set at 11,795 ft. and cemented with 1000 sacks of cement.

Drilling has been carried on almost entirely through blow-out preventers. The well has been cored at frequent intervals, also electrically logged by Schlumberger surveys. Maintaining a vertical hole in this well has been a problem. At 11,505 the hole was six deg. off vertical, so it was plugged back with cement to 10,947 ft. and redrilled. Later, streaks of heaving shale interfered with the progress of drilling, then a gas sand was struck at 11,727 feet. After coring this sand for five ft. (to 11,732 ft.) the gas pressure was such that the well threatened to blow out. It was brought under control. The weight of the drilling mud was increased to 13 lb. per gallon. Another survey of the hole at 11,568 ft. showed it to be four deg. off vertical.

The well again attempted to blow out and the drill stem stuck. This involved a fishing job of cutting and pulling the drill pipe. Not being successful in recovering all the drill stem and in order to prevent further delay, sidetracking was resorted to by milling out of the casing at a depth of approximately 10,800 feet.

By the middle of December, 1936, a depth of 11,760 ft. had been reached in sidetracked hole—about 30 ft. below where blow-out occurred late in September, 1936—without encountering further trouble from high gas pressure.

Late in December a sand showing oil and gas, its top at 12,196 ft., was found. This sand was subsequently penetrated to 12,216 ft., the present depth.

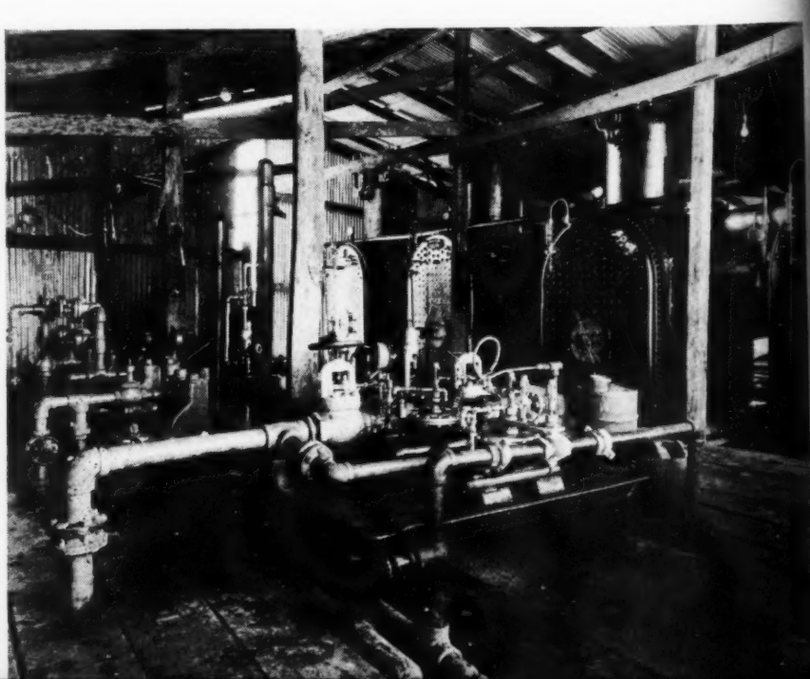
An attempt was made to run a string of 5-in. to 12,196 ft., but about 9600 ft. was as deep as it would go. The pipe was pulled and the hole washed and cleaned, after which the 5-in. was again run with a float shoe and full-hole cementer, and a bit on bottom to aid in working its way down through the heavy drilling mud in the bottom of the hole. It subsequently was set and cemented at a depth of 11,795 ft., about 417 ft. off bottom.

A special string of 2½-in. external upset tubing equipped throughout with Hydril flush joints and a bit on bottom was used as a drill stem to drill out the plugs and mill out the bit on bottom of the 5-in. casing. In drilling-in the well the weight of the mud was increased to a maximum of 18 lb. per gallon.

A production test of the lower sand showed gas and distillate. The pressure at the casinghead rose to 3800 pounds. Subsequently the annular space between the tubing and casing "bridged" and the tubing "froze," after which the casing pressure dropped to zero, and the tubing pressure dropped gradually to 1500 pounds. This resulted in another difficult fishing job of removing the tubing from the well.

At this writing this well is still in the process of completion.

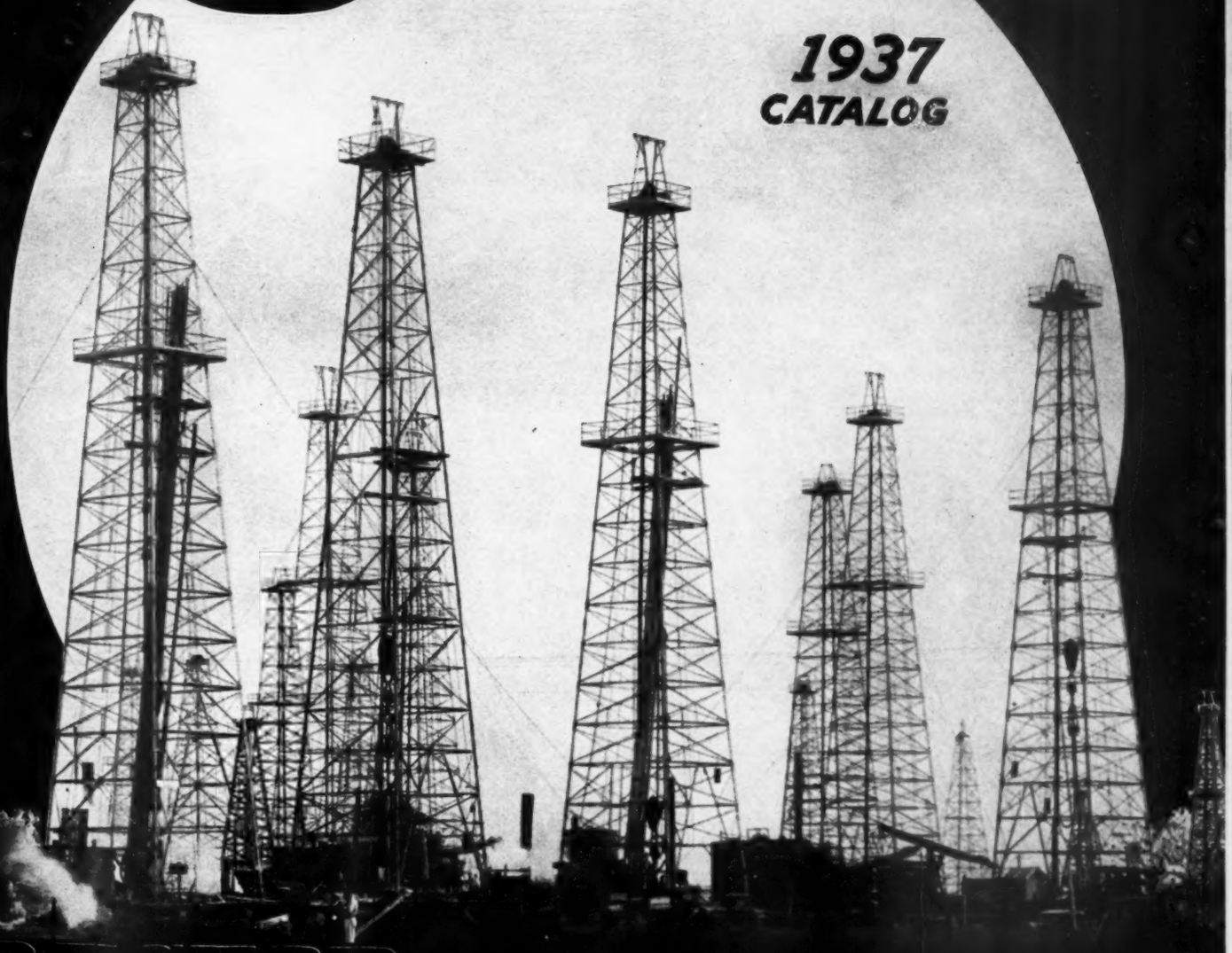
This brief recounting of the trouble encountered on this prospect well gives an inkling of the many difficulties met in bringing in and keeping control of a deep well in wildcat territory where the operator is forced to feel his way as he goes, and at the same time obtain all the information possible on subsurface conditions for guidance in further development work.



Feed pumps and boilers were completely housed

Making the Oil Industry Safer

1937
CATALOG

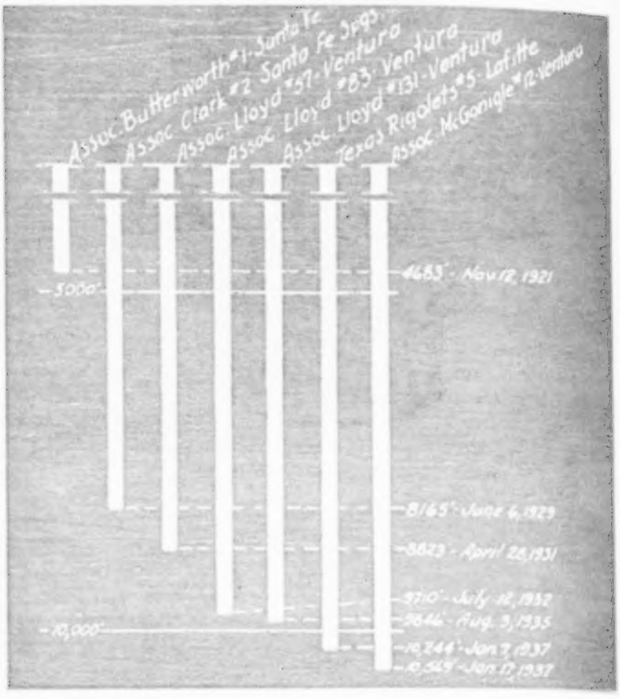


REED ROLLER BIT COMPANY, INC.

FORT WORTH.....TEXAS

WICHITA FALLS TULSA SHREVEPORT HOUSTON
MIDLAND CORPUS CHRISTI

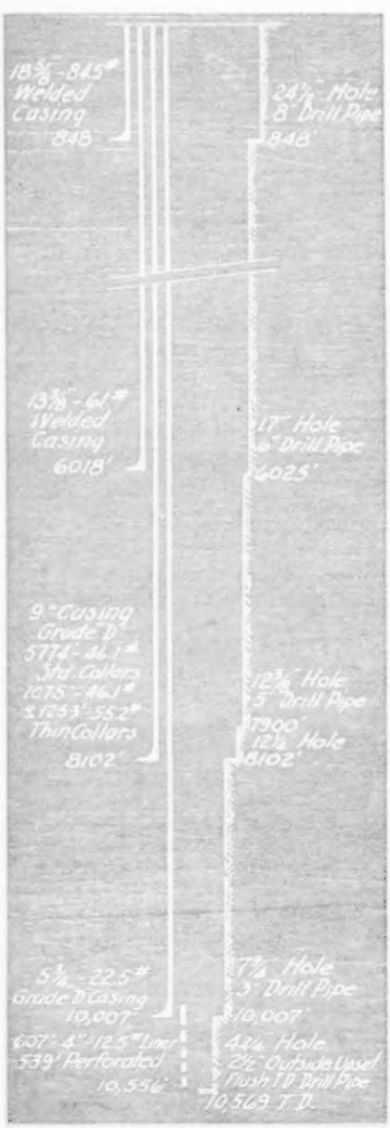
Deepest producing well records held by Tide Water Associated Oil Company, Associated Division; also is included the first producing well below 10,000 ft. drilled by The Texas Company in Louisiana.


Assoc. Butterworth #1 - Santa Fe
Assoc. Clark #2 - Santa Fe
Assoc. Lloyd #57 - Ventura
Assoc. Lloyd #83 - Ventura
Assoc. Lloyd #131 - Ventura
Texas Rigolets #5 - Lafitte
Assoc. McGonigle #12 - Ventura
5000'
10,000'
4683' - Nov. 12, 1921
8165' - June 6, 1929
8823' - April 28, 1931
9710' - July 12, 1932
9846' - Aug. 5, 1935
10,244' - Jan. 7, 1937
10,569' - Jan. 17, 1937

Production from a Depth of Two Miles

By

WALLACE A. SAWDON
Petroleum Engineer, Los Angeles



Completion by the Tide Water Associated Oil Company, Associated Division, of a well two miles deep that produces by natural flow establishes another world's deepest production record. The well is the McGonigle No. 12, 10,569 feet deep, in the Ventura Avenue field, California

ANOTHER world's record for deep production has been established by the Tide Water Associated Oil Company, Associated Division's well McGonigle No. 12 in the Ventura Avenue field, California. This well, now flowing from a depth of 10,569 ft., was completed January 17, 1937, and took the short-lived record for the deepest producing well from The Texas Company's No. 5 Rigolettes Fur Co. in the Lafitte field, Louisiana, which had been completed at 10,244 ft. on January 7. McGonigle No. 12 is the third well in the world to obtain flowing production from a depth below 10,000 ft.; but it is the first to produce from a depth of more than two miles. The Associated thus continues its deep production record-holding that dates back to 1921, as indicated on the accompanying graph.

This well also has made a definite contribution to straight-hole drilling practice, for one of the outstanding features of the McGonigle well is its close limits of vertical deviation. Spudded in during February, 1936, it was drilled with no special equipment but was checked for deviation from vertical at frequent intervals. Its average inclination when completed was less than one degree. At one point it deviated as much as three degrees, but was immediately brought back to vertical by control of the weight carried on the bit. An oriented survey was run to 7600 ft. to check the hole after it had been straightened, and a final oriented survey was made to about 10,000 ft. when the well was completed.

Cores were taken periodically from 800 to 10,007 ft. with rotary core barrels. Electrical logs were made from the shoe of the surface string to the total depth of 10,569 feet. It was the original intention to perforate the 5¾-in. casing, cemented at 10,007 ft., and take production from upper zones. From data supplied by the electrical log, however, indications were that it might be advisable to drill deeper and tap a lower zone. This was done, and after drilling to 10,569 ft. a 4-in. liner (539 ft. perforated) was landed, with its bottom at 10,556 feet. The well

Hole sizes and casing of Associated Well, McGonigle No. 12, Ventura Avenue Field

was then put on production and in 23 hours flowed 533 bbl. of 30.3 deg. A.P.I. oil and 430 thousand cu. ft. of gas through one 55/64-in. bean with a tubing pressure of 20 to 30 lb. and a casing pressure of 500 lb. per sq. inch. This initial flow was cutting 3.6 percent and thus the net production was 536 bbl. of oil daily. At the present time the oil is cutting less than one percent.

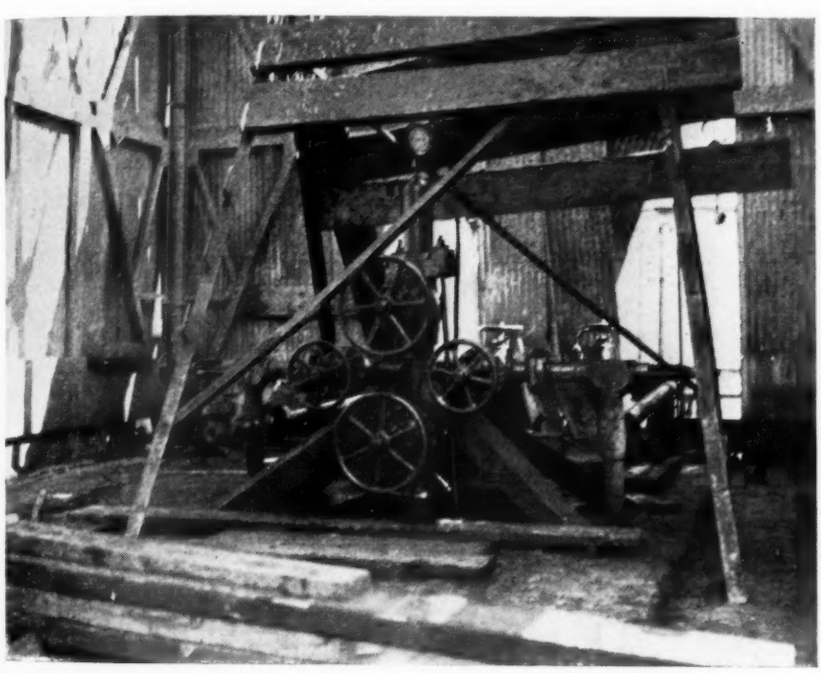
The well probably is drilled to bottom in the fourth zone, which is below the Edison but not so deep as the "57" zone from which some other wells in the Ventura Avenue field are producing. The location is north of the other production in this field and consequently is lower structurally than wells drilled previously.

Various types of drag bits were used in drilling the hole, a 3-way drag bit being used for the last 500 feet. One special bit was used at certain depths and roller type bits with teeth longer than the standard rock bit were employed for hard formations. Reamers were used above the bit and a weight indicator was used for governing the weight carried on the bit at all times. From 10,007 ft. to the bottom of the hole drilling was easy, this distance being made in 16 days, an average of 35 ft. daily.

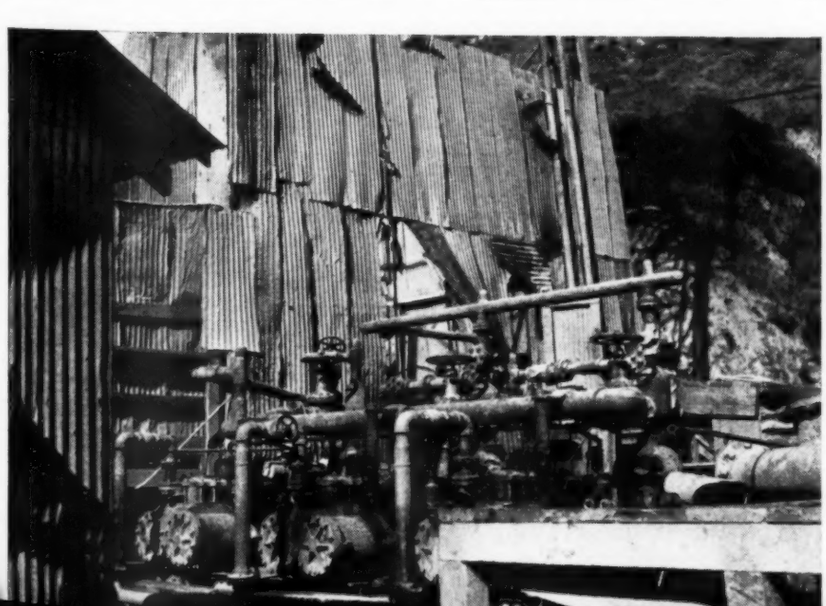
Mud from the company's reclamation plant in the Ventura Avenue field, weighing from 73 to 74 lb. per cu. ft. (9.8-9.9 lb. per gal.), was used for circulation until the hole struck an appreciable volume of gas. When pulling tools, however, new "yellow" mud was spotted in. This yellow mud also was used for the deeper drilling, weight material being added when necessary. At one time the mud weight was increased to 100 lb. per cu. ft. (13.4 lb. per gal.), but it was felt that such weight hardly was necessary.

The casing and hole record of the well is shown in an accompanying illustration. Two further records were established in casing the hole: (1) It was the longest string of welded casing yet run; this was the 13⅜-in.—61 lb. string and was cemented at 6018 feet; (2) time record was established with the 5¾-in. pipe, which was run to 10,007 ft. in a total elapsed time of 8 hours and 45 minutes. This casing was equipped with a late design of threaded connection, flush inside and upset outside. The time consumed in running the string included one and one-half hours circulating time, thus the 350 joints of casing were run in an average time of 50 joints per hour.

The deepest producing well in the world. Tide Water Associated Oil Company, Associated Division, Well McGonigle No. 12, Ventura Avenue Field, California



The Christmas tree installed and the well flowing—McGonigle No. 12, Ventura Avenue Field



No attempt was made to set a record when the casing was run, but its speedy running was desired to prevent any chance of mud settling to bottom before the casing was landed.

All strings were floated in, and below the surface pipe each casing string was equipped with a float shoe on bottom and a float collar one joint above. The float shoes and collars aided in the cementing operations and no trouble

Three 14-in. by 7-in. by 14-in. pumps handled the circulation adequately

2 miles straight down!"

. . . But crews never worry with a BJ '300' Triplex Hook, Weldless Links and Slip Casing Elevator on the job.

Congratulations to Associated Division of Tidewater Associated Oil Company as oil is today being produced from McGonigle No. 12 at world's record depth.

And thank you for giving BJ Tools an opportunity to demonstrate their operating convenience and complete safety on wells 10,569 feet deep.

Judging from their satisfied expressions, this crew using BJ TONGS must have "sized up" that big BJ TRIPLEX HOOK, and decided it could handle 10,569 feet of drill pipe.

BJ

BYRON JACKSON CO.
AND SUBSIDIARY
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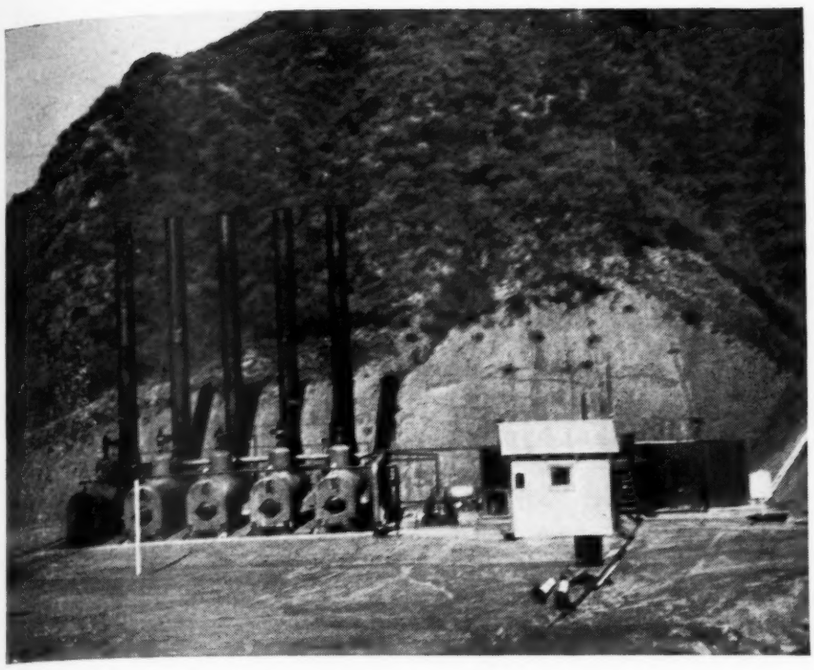
DRILLING AND PRODUCTION TOOLS



The battery of five boilers used in drilling the well

whatever was experienced in cementing any of the strings.

The 18⅝-in. welded surface pipe was cemented from the bottom with 750 sacks of cement and from the top with 200 sacks pumped in between the casing and the wall of the hole through 2-in. tubing. The 13⅜-in. string was cemented with 1000 sacks, the 9-in. with 640 sacks, and the 5¾-in. with 350 sacks.

The only piece of surface equipment that could be considered specially devised for drilling this well was a large size triplex hook used while drilling the last 2000 feet. The wire line employed was 1-in. in diameter, the size used by the company in drilling all its deep wells in the Ventura Avenue field. Drawworks and other equipment were similar in weight and design to those previously employed and included auxiliary or standby units. A 2½-in. rubber rotary hose was used to 8000 ft.; a 3-in. to 9800 ft., and a 3-in. steel hose from 9800 ft. to bottom.

The prime mover was a 12-in. by 12-in. twin steam engine and the auxiliary engine a twin 10-in. by 10-inch. Three 14-in. by 7-in. by 14-in. mud pumps handled circulation adequately. Steam was supplied at a pressure of 175 lb. by a battery of five boilers of the low-pressure type.

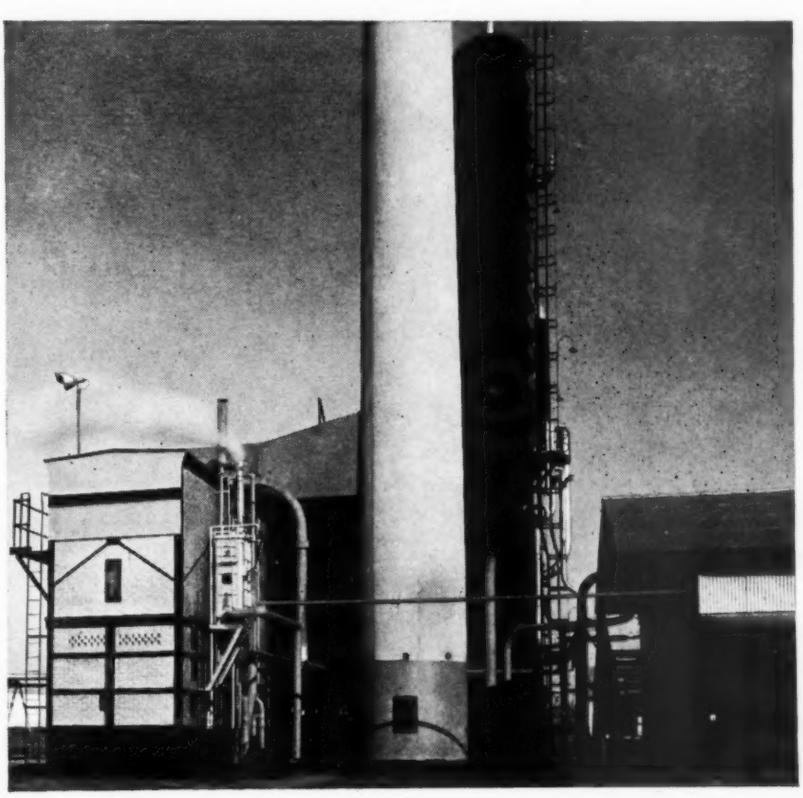
Successful completion of such wells as the McGonigle No. 12 presage the greater depths from which production may be common in the not far distant future. Wells below the two-mile depth can be drilled and completed successfully without difficulty with present-day equipment when careful and intelligent drilling practice is followed. Such wells as this contribute to modern drilling technique and serve as markers of progress in the drilling and producing branches of the oil industry.

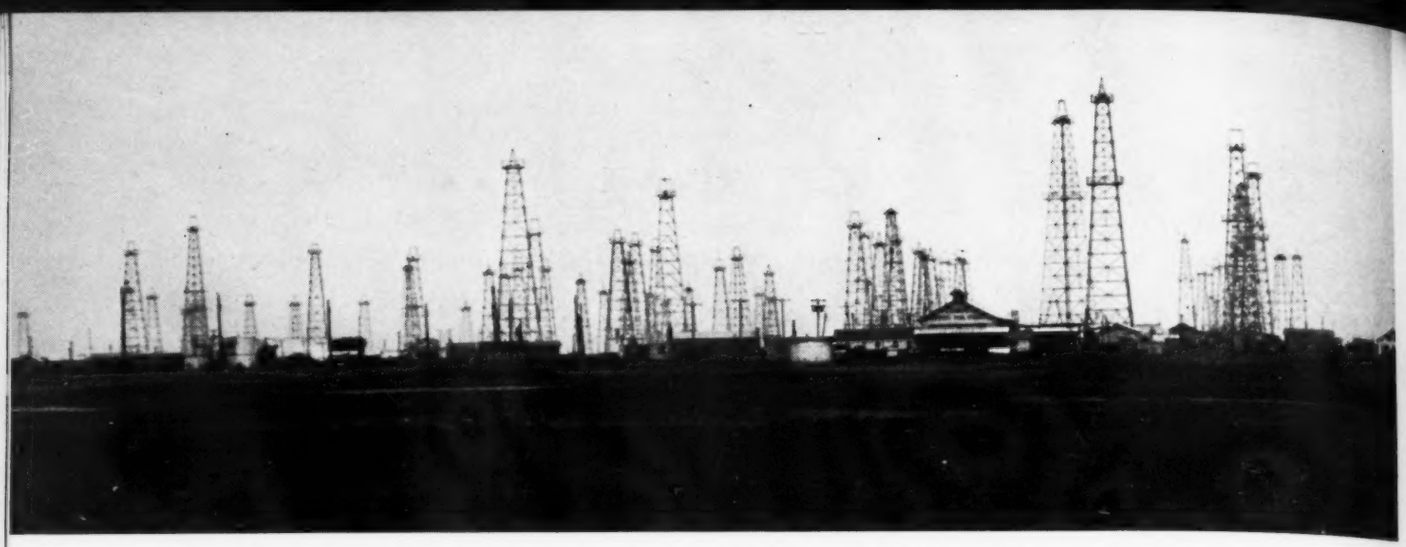
OUTSIDE BOILER INSTALLATIONS

SINCE the initial installation of an outside boiler, made at the Longview, Texas, refinery of the Premier Oil Refining Company, considerable interest has been aroused in this type unit, eliminating as it does the need for a boiler house building.

Sylvester Dayson, president of the Premier Oil Refining Company, was first to instigate the idea, suggesting that the design of a boiler installation being somewhat similar to that of an oil heater, it could be installed in the same manner as an oil heater. As a result, the unit shown in the accompanying illustration was designed and installed by Henry Vogt Company. The photograph was taken after the unit had been in service two and a half years.

Several more units of the same type have been installed within recent months, and at the present time others are being erected.





General view of the townsite section of the Talco field. The area is divided into two parts, the one shown here and the southwest end of the field. A number of the wells shown are right in the heart of the town of Talco

Development Operations in the Talco Field

By W. H. GRAYSON

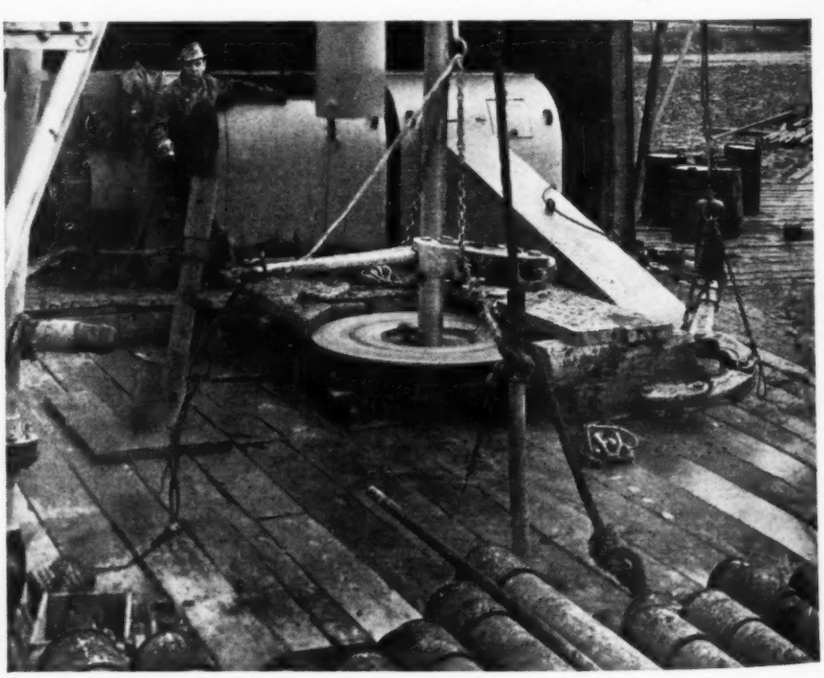
Field is one year old and has bright prospects for future drilling. A retarding factor has been the lack of water for drilling operations

THE Talco oil field of northwestern Titus County, Texas, celebrated it's first anniversary early this month. A deep field, with production coming from the Paluxy sand in the upper Trinity series, the area was opened one year ago when the Housh and Thompson, Inc., R. L. Peveto No. 1 C. M. Carr test, one-half mile from the town of Talco, made two heads of oil at about 11 o'clock on the night of February 7. Coming in unexpectedly, driller Mike Langley and his crew acted instantly as the flow of oil began, loading the well with mud to prevent it from flowing wild, or becoming a raging inferno from the flames of the boiler furnaces near the derrick.

Under swaying electric lights, in the teeth of a cold, blue February norther, drillers forced mud down the hole of the No. 1 Carr and another oil field was added to the large total for the state of Texas.

The Talco discovery marked the beginning of commercial oil production from the Paluxy sand of the Trinity series, found between the depths of 4100 and 4300 feet. Upon previous unsuccessful efforts to find oil in Titus, Hopkins, and Lamar counties, drilling had been only to the Woodbine, the producing sand of the great East Texas field. Tests had been drilled as far back as 1916, 60 miles from the nearest oil production, and now many of these old abandoned holes are likely to redrilled and deepened to the Paluxy sand. Geologists are of the opinion that the same strata from which the Powell and Mexia oil fields produce, and also the Balcones fault line, persist through the Talco sector.

C. M. "Dad" Joiner, who discovered the East Texas oil field six years ago, the largest in the world, had long believed in the area northwest of the East Texas field. He staked 40,000 acres in Titus, Hopkins, Morris, and Franklin counties and today his holdings are immensely valuable. Because it is a deep field and the reservoir pressure low, wells usually are placed on the pump. It is generally believed that the field will have a long life.

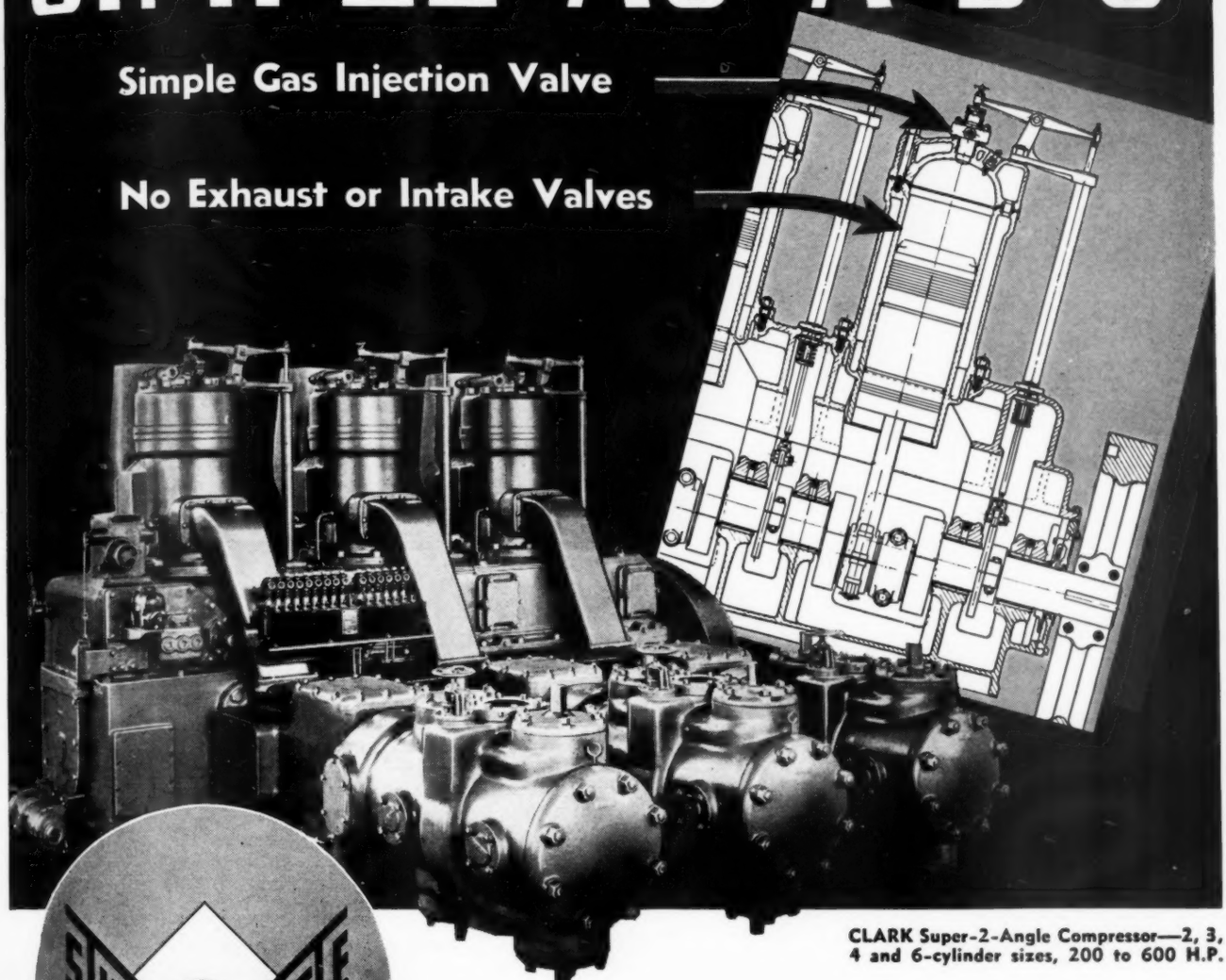


On the derrick floor of Tide Water well, No. 2 Wilson, Talco field. This well is being drilled by Housh, Schofield and Thompson, drilling contractors, and is down 3260 feet

SIMPLE AS A-B-C

Simple Gas Injection Valve

No Exhaust or Intake Valves



CLARK Super-2-Angle Compressor—2, 3, 4 and 6-cylinder sizes, 200 to 600 H.P.

SUPER 2 ANGLE

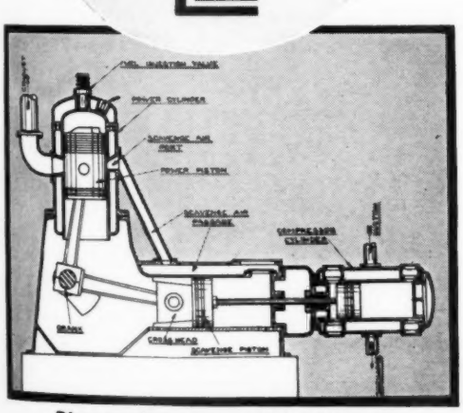


Diagram shows scavenging piston attached to compressor crosshead to produce 25% excess scavenging air.

The extreme *mechanical simplicity* of the CLARK Super-2-Angle Compressor has made an instant appeal to oil industry engineers. The principle of few, sturdy parts has been adhered to throughout. Note these advantages:

No exhaust or intake valves—Simple fuel-injection valve—one power cylinder for each compressor cylinder—25% excess scavenging air, through simple, improved method. Full force feed oiling system and oil-cooled piston which maintains low crank case temperatures and eliminates carbon troubles in crank case.

CLARK "Super-2-Angles" bring these economies: (1) Substantial reductions in floor space and foundation requirements; (2) Low fuel consumption; (3) Lowest maintenance. It will pay you to investigate.

See CLARK Section, 1937 Composite Catalog

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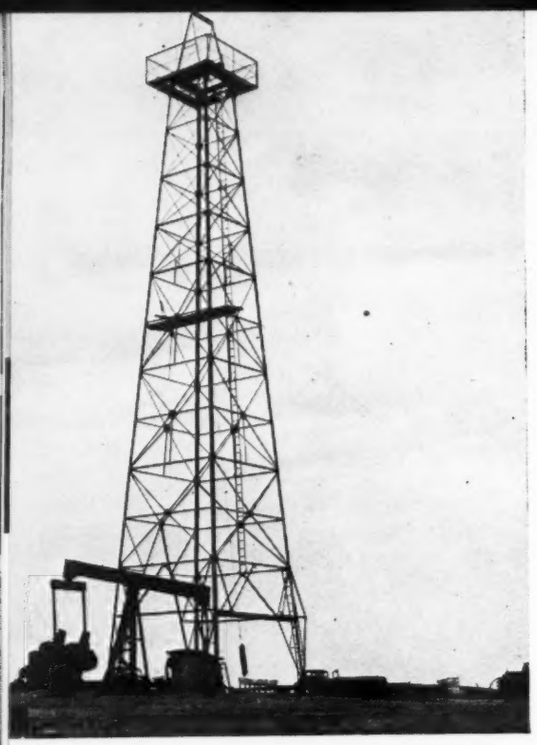


Housh and Thompson, Inc., No. 1 Peveto, discovery well in the Talco area. This well was brought in Friday, February 13, 1936, about a year ago

The majority of wells in the Talco field are brought in after being gun-perforated. Wells are drilled in the usual manner until the desired depth is reached, after which a Schlumberger test usually is run. After determining how much saturated sand is exposed in the well, and at what depth, pipe is set on bottom and cemented for approximately 800 feet. Liner is then gun-perforated after the cement has set for 72 hours. This procedure is almost necessary because the reservoir pressure is insufficient to flow wells naturally and the Paluxy sand is of such fine texture that there is danger of plugging the face of the sand. Oil from the Paluxy sand is dark and its gravity 14 to 26 deg. A.P.I. Detailed analyses of crude from two Talco wells, made by the U. S. Bureau of Mines, are given in Tables 1 and 2.

One company operating in Talco utilizes the air-lift method of flowing its wells. The compressor is 13½ by 5½ by 12 heavy-duty, V-angle, direct-connected gas-engine-driven unit. It is complete with a gasoline-engine-driven 2-stage starting air compressor mounted on an 80-gal. air receiver. A circulating water pump is attached to the main unit for circulation of water from cooling tank through the unit to the top of the cooling tower. This compressor is a 125-hp. unit having a piston displacement at 300 r.p.m. of 600 cu. ft. per minute. There is a clearance pocket in the L.P. outer compressor cylinder head that permits the unit to operate at varying pressures up to 1000 lb. discharge pressure. The 3-in. high-pressure discharge line from

TABLE 1

Carr Well No. 1 (discovery well) Talco Field — Texas
4190-4208 feet — Paluxy Sand, Lower Cretaceous — Titus County
Pleasant Oils, Inc.

GENERAL CHARACTERISTICS

Specific gravity 0.907
Percent sulphur 2.77
Saybolt Universal viscosity at 100°F. 200 seconds
Saybolt Universal viscosity at 130°F. 115 seconds
A.P.I. gravity 24.5°
Pour point below 5°F.
Color brownish black

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

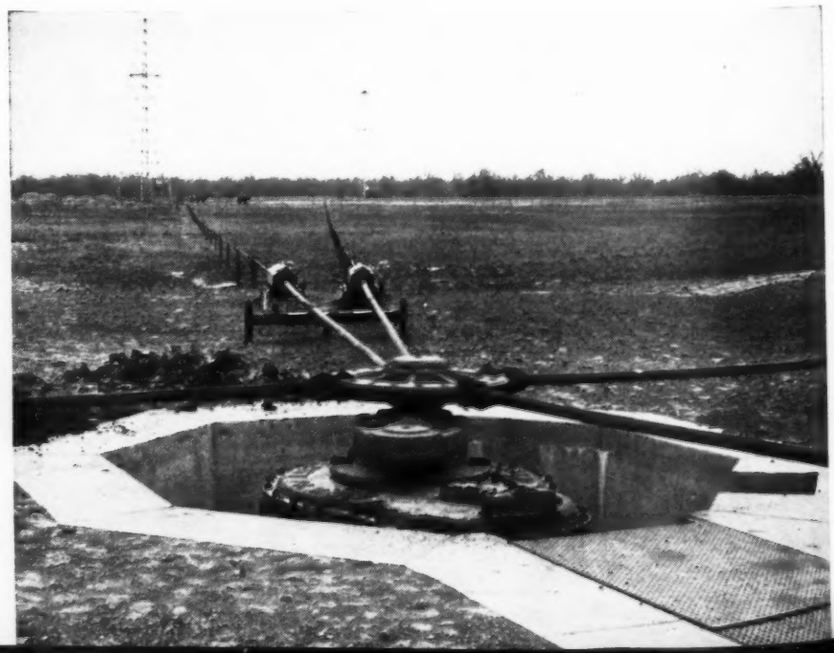
Dry distillation — Barometer 737 mm. — First drop: 38°C. (100°F.)

Temperature °C.	Percent cut	Sum Percent	Sp. gr. of cut	°A.P.I. of cut	Viscosity at 100 °F.	Cloud test °F.	Temperature °F.
Up to 50							Up to 122
50 to 75							122 - 167
75 - 100	3.7	3.7	0.669	80.0			167 - 212
100 - 125	2.3	6.0	.711	67.5			212 - 257
125 - 150	2.3	8.3	.736	60.8			257 - 302
150 - 175	2.8	11.1	.756	55.7			302 - 347
175 - 200	2.5	13.6	.776	50.9			347 - 392
200 - 225	3.0	16.6	.792	47.2			392 - 437
225 - 250	3.9	20.5	.808	43.6			437 - 482
250 - 275	6.0	26.5	.824	40.2			482 - 527
Vacuum distillation at 40 mm.							
Up to 200	2.7	2.7	.855	34.0	41	10	Up to 392
200 - 225	5.4	8.1	.863	32.5	45	25	392 - 437
225 - 250	5.3	13.4	.880	29.3	56	45	437 - 482
250 - 275	5.1	18.5	.894	26.8	80	60	482 - 527
275 - 300	6.9	25.4	.903	25.2	130	80	527 - 572

Carbon residue of residuum 17.1% — Carbon residue of crude 8.0%

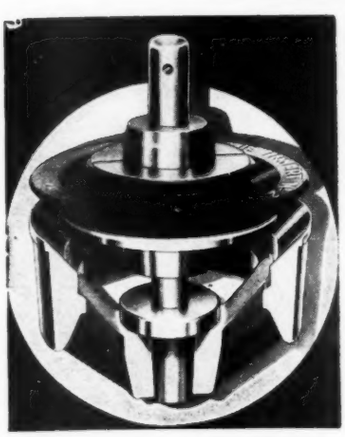
APPROXIMATE SUMMARY

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	3.7	0.669	80.0	
Total gasoline and naphtha	13.6	.725	63.7	
Kerosene distillate	12.9	.812	42.8	
Gas oil	7.9	.862	32.7	
Nonviscous lubricating distillate	10.5	0.871-0.897	31.0-26.3	50-100
Medium lubricating distillate	7.0	.897- .908	26.3-24.3	100-200
Viscous lubricating distillate	.....	.....	.....	Above 200
Residuum	46.6	0.999	10.1	
Distillation loss	1.5	.....	.....	



Power on the Humble Oil and Refining Company property in the extreme west end of the Talco field. It is driven by a 160-hp. twin engine and is pumping five wells; another well is about to be added

A PUMP IS ONLY AS GOOD AS ITS... VALVES *and* PISTONS



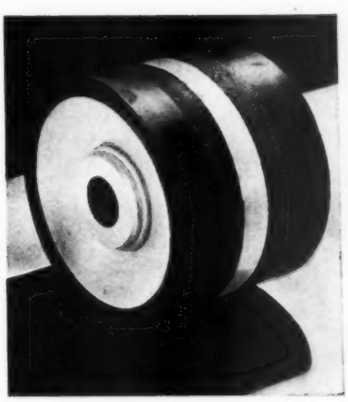
NEW MISSION SILVER TOP SLUSH PUMP VALVES LAST 100% LONGER

Time proven Mission Principle of wear-taking removable bushings in a long-lasting seat

★**SAVES MONEY**
formerly invested in continuously buying new seats.

★**SAVES LABOR**
of changing seats often.

NEW BUSHING IS TAPERED—a progressive Mission improvement that holds the bushing firmly in place, eliminating wear on bottom of bushing, and valve seat under bushing... Easily changed by using attachment on Mission seat puller.



IMPROVED MISSION SLUSH PUMP PISTONS CUT UPKEEP COSTS IN HALF

Replaceable rubbers on a long-lasting body.

★ **SAVES MONEY**
formerly invested in continuously buying complete new pistons.

★ **LIFE OF LINERS AND PISTONS INCREASED**

Principle of more-rubber and less-metal gives three-times-greater wiping surface, eliminating by-passing.

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MISSION MANUFACTURING CO.

HUMBLE ROAD » » HOUSTON, TEXAS

MISSION VALVES..MISSION SLIPS..MISSION PISTONS..MISSION SWABS

SOLD THROUGH SUPPLY STORES EVERYWHERE

Typical pumper showing casinghead connections and jack used. This is the Humble Oil and Refining Company's No. 18 King with the pump shown in operation

TABLE 2

King Hughes Well No. 1
4181 (?) - 4197 feet
Humble Oil and Ref. Co.

Talco Field
Paluxy Sand, Lower Cretaceous

Texas
Franklin County

GENERAL CHARACTERISTICS

Specific gravity 0.904
Percent sulphur 2.76
Saybolt Universal viscosity at 100°F. 180 seconds
Saybolt Universal viscosity at 130°F. 115 seconds
A.P.I. gravity 25.0°
Pour point 15°F.
Color brownish black

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry distillation — Barometer 737 mm. — First drop: 85°C. (185°F.)

Temperature °C.	Percent cut	Sum Percent	Sp. gr. of cut	°A.P.I. of cut	Viscosity at 100 °F.	Cloud test °F.	Temperature °F.
Up to 50							Up to 122
50 - 75							122 - 167
75 - 100	3.6	3.6	0.671	79.4			167 - 212
100 - 125	2.1	5.7	.705	69.2			212 - 257
125 - 150	3.1	8.8	.732	61.8			257 - 302
150 - 175	2.1	10.9	.755	55.9			302 - 347
175 - 200	2.8	13.7	.772	51.8			347 - 392
200 - 225	3.2	16.9	.790	47.6			392 - 437
225 - 250	3.8	20.7	.805	44.3			437 - 482
250 - 275	6.2	26.9	.822	40.6			482 - 527
Vacuum distillation at 40 mm.							
Up to 200	3.1	3.1	.855	34.0	40	10	Up to 392
200 - 225	5.2	8.3	.863	32.5	45	25	392 - 437
225 - 250	5.2	13.5	.880	29.3	57	45	437 - 482
250 - 275	5.0	18.5	.894	26.8	80	60	482 - 527
275 - 300	6.5	25.0	.903	25.2	130	80	527 - 572

Carbon residue of residuum 16.6%
Carbon residue of crude 7.8%

APPROXIMATE SUMMARY

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	3.6	0.671	79.4	
Total gasoline and naphtha	13.7	.724	63.9	
Kerosene distillate	13.2	.809	43.4	
Gas oil	8.0	.861	32.8	
Nonviscous lubricating distillate	10.3	0.870-0.897	31.1-26.3	50-100
Medium lubricating distillate	6.7	.897- .908	26.3-24.3	100-200
Viscous lubricating distillate	----	----	----	Above 200
Residuum	47.0	0.996	10.6	
Distillation loss	1.1	----	----	

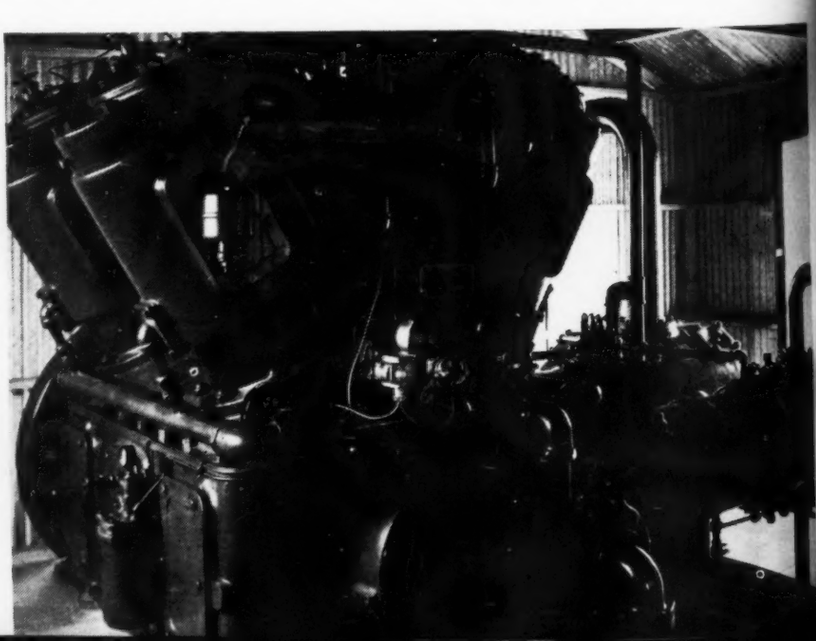
the compressor is carried the length of the lease. A 2-in. lateral runs from the main line to each well.

The size of casing in most of the wells is 5 3/16-in. 17-lb. seamless; the tubing 2½-in. external upset. Each well is equipped with an average of 14 Bryan flow valves in a closed system, using a hook wall packer. The packer is set just above the perforations in the casing, and a standing valve is placed immediately below the packer. The packer and standing valve are necessary due to the low-productivity index of the wells.

The average working pressure on the wells is 450 pounds. Pressure is admitted to the casing and flow is through the tubing into 4-in. flow lines to tanks. No separator is used ahead of the tanks.

Twelve wells are connected to the compressor station. Production is obtained by intermittent operations manually controlled. Air is used for lifting since no gas is available.

The compressor, construction work, ditching for and covering of the pipe line, valves and fittings, and the valve equipment on the tubing cost $24,000 —an average of $2,000 for each well flowed by the compressor. Due to the unusual production problems presented in the area, namely high-viscosity and low-productivity index, this air-lift installation has attracted considerable attention among operators.



Compressor unit at the central air-lift plant of the G.M.W. Oil Company at Talco. This plant is now operating at but a fraction of its capacity in anticipation of other producing wells being added to its load

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With Fusion Welded Barrels

Farrar & Trefts, boiler manufacturers for seventy-five years, pioneered the fusion welded barrel construction. Advantages of this type of construction are: 1. *Uniform barrel diameter with equal stresses at all points.* Movements of straps and rivets are eliminated and this, in turn, eliminates possible leakage. 2. *A considerable saving in weight.* This makes handling and moving less difficult and less expensive. 3. *Straight and smooth inside.* This makes for easier and quicker washing and cleaning.

All welds are radiographed to show thorough penetration and fusion, the welding being in full accord with the A.S.M.E. Boiler Construction Code.

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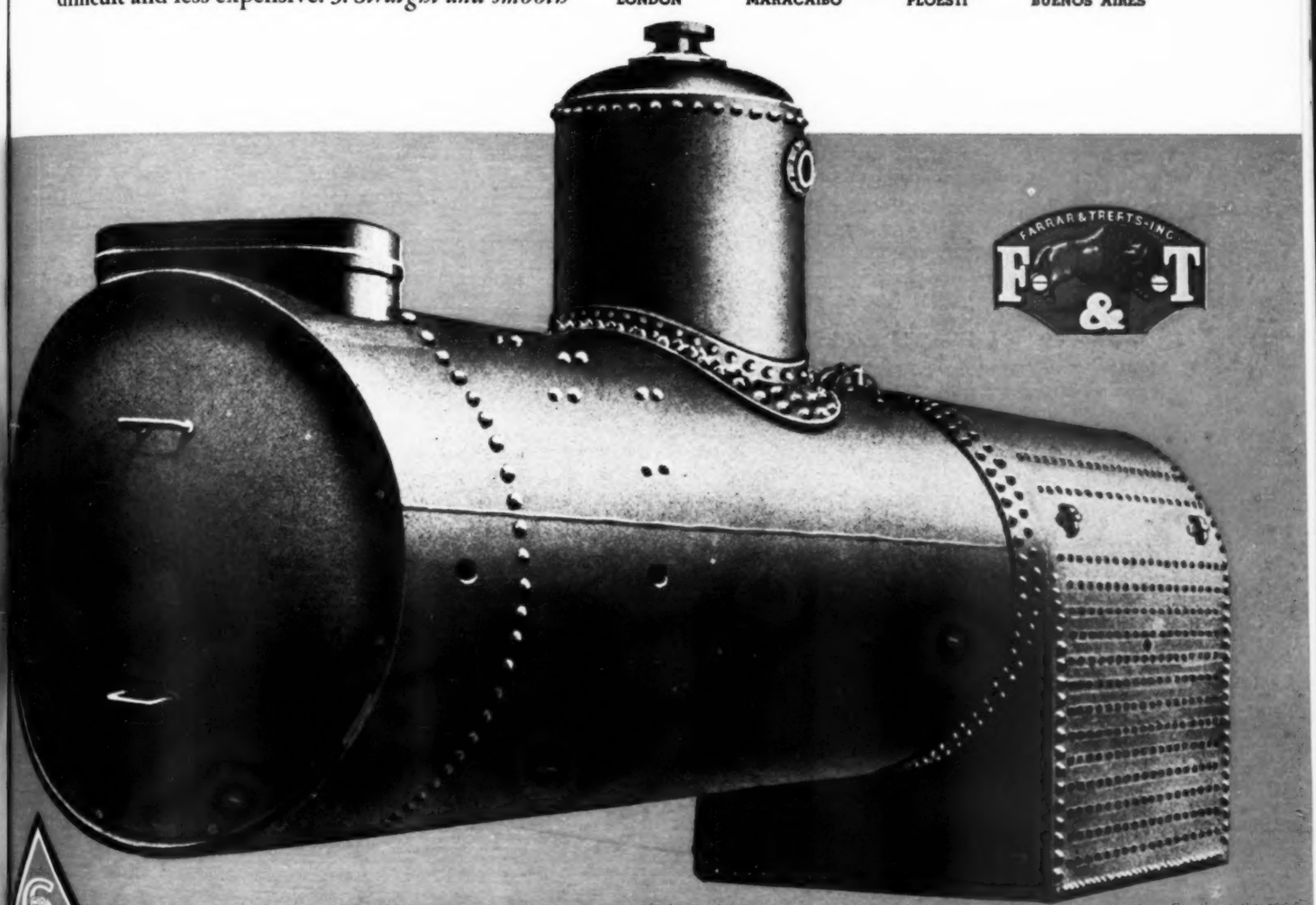
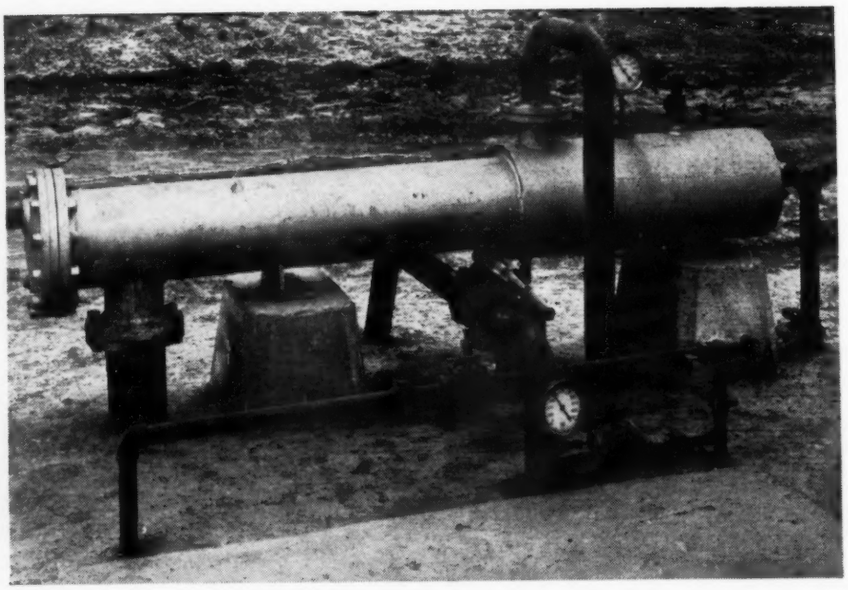


"SERVING THE OIL AND GAS INDUSTRIES"

CONTINENTAL



Pre-cooler used in connection with the G.M.W. Oil Company's air-lift in the Talco Townsite field. Here the air is cooled before it goes to the wells

Because of the lack of water facilities, and the soft, black soil, usually but two wells can be completed during a month with a single rig in the Talco area. This shortage of water constitutes a serious impediment to drilling. With more than 225 deep producing wells in the area, smaller operators now holding leases in the field proper face a loss of their holdings because of lack of water for drilling purposes. Practically every lease carries a time limit clause, and wells must be started and completed within a certain stipulated period.

The Humble Oil and Refining Company, largest operators in the field, have their own water lines from Mt. Pleasant, 18 miles away, and the Constantin and Company refinery has a line for drilling their own wells and supplying the needs of their refinery. Although a $200,000 water and sewerage project is under way for the City of Talco, workmen still are drilling for water unsuccessfully for the city system, and none has been found to date.

One deep water well is situated approximately five miles north of Talco and water from this source is sold for drilling purposes. The well can supply the daily water requirements for five rigs, and is in use 24 hours each day because of the pressing needs of operators. Many tests have been shut down because of this lack of water.

The well is owned by the Drilling Water Service Company of Talco, and water is pumped the 5-mile distance to Talco under a pressure of approximately 100 pounds. One oilfield boiler supplies the power and two mud pumps boost the water through a 6-in. line to the drilling wells. A Diesel engine operating a 42-hp. rotary pump having a maximum rated speed of 7,250 r.p.m., is employed to raise the water to the surface and deposit it in a deep pit, whence it is pumped into the lines direct to the drilling wells.

No prospects are in sight for better water facilities for this deep field, and although a $6,000,000 drilling campaign is planned for 1937 by major and independent companies, the water shortage in the area constitutes the major problem.

The average cost of drilling a well in Talco is approximately $20,000, compared with an average of $7,500 per well in the East Texas field.

Among the largest operators in the Talco area are the Humble Oil and Refining Company, The Magnolia Petroleum Company, Lucey-Byrd-Frost Company, and the G. & M. W. Oil Company. Two pipe lines transport the oil to East Texas refineries and one line relays the crude to Mt. Pleasant, 18 miles away, where it is loaded into tank cars. One refinery, the Constantin & Company plant, was completed February 1, and the Lucey-Byrd-Frost Company is now constructing one that will have a daily capacity of 5000 barrels. More than 225 producers now dot the Talco field, and in the development of Sulphur Bluff field nearby the 18th producer has just been completed.

J. C. Norman, engineer in charge of the air-lift plant operated by G.M.W. Oil Company in the Talco field, is shown opening the flow valve on Well No. 1, Block 35, of the townsite field

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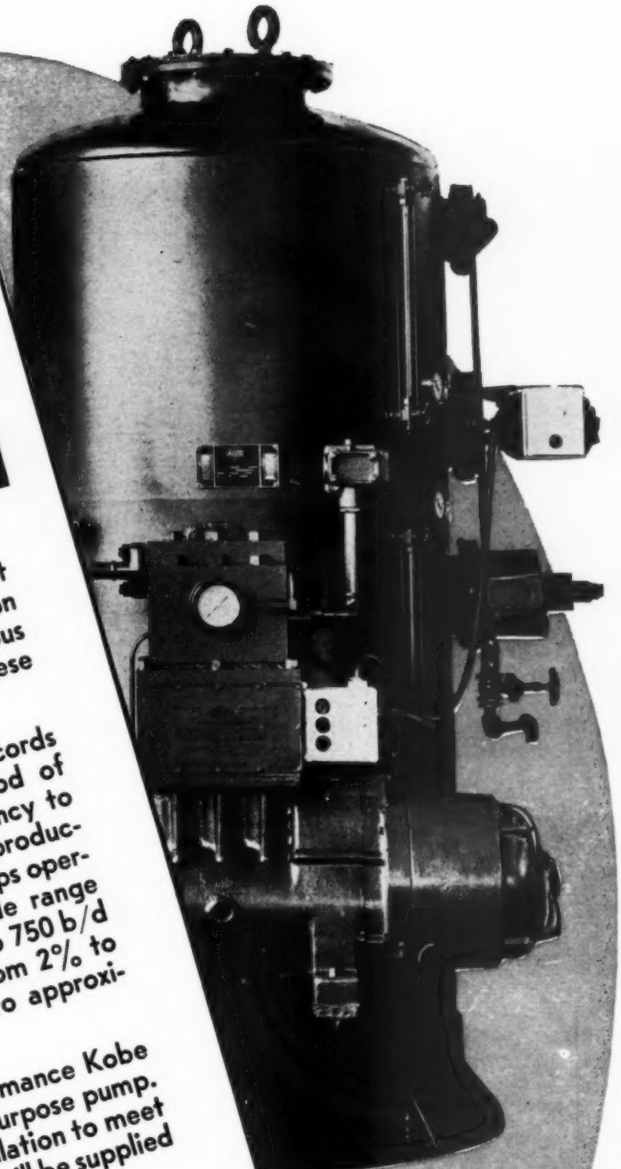
DOES *not* EMULSIFY PRODUCTION



"Cut oil" long has been an important problem in petroleum production. Agitation of the water and oil resulting from various lifting methods serves to intensify these emulsion problems.

Carefully maintained operating records definitely show that the Kobe method of pumping does not involve any tendency to increase the emulsion "cut" of wet production. These are records of Kobe Pumps operating in various fields under a wide range of conditions, producing from 10 to 750 b/d of crude with a water "cut" of from 2% to 75%, from depths ranging up to approximately 9,000 feet.

On the basis of actual performance Kobe has been aptly termed the all-purpose pump. Complete data covering installation to meet specific production problems will be supplied without obligation.

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THE ALL-PURPOSE PUMP

KOBE PUMP

Bleaching Clay

« PART 1 »

By RAFAEL FUSSTEIG

A discussion of the theoretical and technical considerations of this valuable product in petroleum refining

Origin and Composition of Bleaching Clay

BLEACHING clay is used extensively in the manufacture of petroleum products to remove suspended, colloidal, and dissolved impurities, such as carbon or coke, resinous and asphaltic substances, especially those rich in combined oxygen, hydrocarbons poor in hydrogen, or coloring matter, and to increase the chemical stability, and neutralize acid-treated oils without the application of alkaline solutions and washing with water.

Bleaching clay can be used for many purposes in place of sulphuric acid and often to much greater advantage. The use of bleaching clay in decolorizing vegetable and animal oils is no invention of modern time; it was known long before the beginning of our era. There are to be seen on certain Egyptian tablets slaves clarifying olive oils by means of earths, and the Chinese knew for hundreds of years of certain clays that decolorized vegetable and animal oils.

This working process, however, dropped into oblivion during the middle ages, the process first being introduced in the United States in the soap industry, and later in the oil-refining industry. On light oils, bleaching clay is used more generally for the improvement of color, though it is used for other purposes also, such as the removal of acid, traces of alkalies and soaps, and the reduction of gums, and, to a slight extent, of sulphur. The bleaching clay also has some value as a catalyst for chemical reactions in the manufacture of by-products, as well as in cracking. The use of bleaching clay has been recommended for the prevention of "sludge" deposits in insulating oils. For example, the "Compagnie française pour l éxploitation des procédés Thomson-Houston"[1] recommends the addition of fuller's earth to transformer oils in order to prevent deposition of solids or mud in transformers.

Not all silicates possess these characteristics, being dependent to a high degree upon their interior structure. Before entering into a discussion of this matter, however, it is desirable to discuss the origin and composition of bleaching clays. Silicon dioxide is the most simple chemical combination of the silicates, this combination being submitted to various chemical reactions with hydroxides of aluminum, magnesium, calcium, potassium, sodium, etc., under certain conditions during the consolidation of the earth. For example, the chemical combination of three molecules of silicon dioxide with two molecules of potassium hydroxide and two molecules of calcium hydroxide formed feldspar, according to the following equation:

$$3SiO_2 + 2KOH + 2Al(OH)_3 \longrightarrow 2KAlSiO_3.$$

This feldspar was submitted during many thousands of years to a permanent degradation under the influence of the atmospherical carbonic acid and water. This process of weathering occurred in such a manner that carbon dioxide and aqueous vapors of the atmosphere attacked chemically the interior structure of this silicate, thus forming new combinations. The transformation of feldspar into kaolin and a water-soluble kaolin silicate can be expressed as follows:

$$2KAlSi_3O_8 + 2H_2O \longrightarrow Al_2H_4Si_2O_9 \text{ (Kaolin)} + 2H_3KSiO_6.$$

During the course of many thousands of years kaolin silicate went through a leaching process as a result of the action of water currents, and since considerable of this combination was split up from the feldspar, kaolin, a loose and porous material, was formed.

Feldspar, of course, also has been transformed into bleaching clays. In this instance, the weathering process has caused a splitting up of the feldspar in such a manner that two combinations were formed, that part insoluble in water being of microscopic structure with ultramicroscopic channels, whereas that soluble in water was consolidated in these channels. Under the influence of the water currents and carbonic acid, this soluble silicate was subjected to a leaching process, resulting in the formation of a great adsorption surface. Such silicates are able to decolorize oils, paraffin waxes, etc.

Many sorts or silicates exist that have microscopic channels, those of the finest microscopic structure being called zeolites. These zeolites generally are hydrated aluminum silicates of calcium or sodium and their empirical formula shows a silicate of the feldspar group bound with water, this water being combined partly or entirely with the foregoing silicates. The zeolites are acid salts in which a part of hydrogen is substituted by the group $CaAl_2O_2$, or NaAlO. The formula of zeolites therefore can be expressed so that the first part appears as a normal salt, while the second part shows a silicic acid, which frequently is bound with crystallization water.

$Na_2O.Al_2O_3.4SiO_2.2H_2O$ = Analcime, as $:Na_2Al_2Si_2O_8.2H_2SiO_3$,

$CaO.Al_2O_3.4SiO_2.4H_2O$ = Laumontite, as $:CaAl_2Si_2O_8.2H_2SiO_3.2H_2O$,

$Na_2O.Al_2O_3.3SiO_2.2H_2O$ = Natrolith, as $:Na_2Al_2Si_2O_8.H_4SiO_4$,

$CaO.Al_2O_3.3SiO_2.3H_2O$ = Scolezite, as $:CaAl_2Si_2O_8.H_4SiO_4.H_2O$,

$CaO.Al_2O_3.6SiO_2.5H_2O$ = Stilbite, as $:CaAl_2Si_4O_{12}.2H_2SiO_3.3H_2O$,

$CaO.Al_2O_3.6SiO_2.6H_2O$ = Desmine, as: $CaAl_2Si_4O_{12}.2H_2SiO_3.4H_2O$.

Zeolites seldom exist in a free state, but frequently are found mixed with other argillaceous earths. The greater the content of zeolites in an argillaceous earth the more suitable it is as a bleaching clay. Such natural bleaching clays are known as fuller's earth. It is seen that there are many differences between the kaolins and zeolites, both chemically and physically. Kaolin has a very slow adsorption rate, while the zeolites, viz., the fuller's earths, have a high capacity for adsorbing basic colors, and can remove these colors from solutions in animal, vegetable, and mineral oils, as well as from some other liquids, especially water. On the other hand, kaolin is extremely resistant to the action of acids, while

(Continued on page 101)

(Continued from page 98)

zeolites are easily attacked, and give a precipitation of free silicate.

Frey, Yovanovitch, and Burghelle[2] have studied this problem on bleaching clays from North Africa, and have contributed interesting observations concerning the characteristics of kaolin and fuller's earth. According to them fuller's earth or the activable argilleceous earths may be considered as halloysite $2SiO_2.Al_2O_3.2H_2O + H_2O$, or as montmorillonite $4SiO_2.Al_2O_3.2H_2O + H_2O$, or when in the form of bentonite they present a combination of montmorillonite and magnesium silicate of the formula $5SiO_2.Al_2O_3.(Mg, Ca)O.nH_2O$. Bentonite also can contain baddeleyite $3SiO_2.(Fe, Al)_2O_3.nH_2O$. According to the opinion of these investigators, fuller's earth also may be represented in the group of palygorsquites, this group being an isomorphic mixture of sepiolite $4SiO_2.5MgO.H_2O + H_2O$ and paramontmorillonite. Their investigations, conducted on the leaching processes of halloysite, montmorillonite, and kaolin, revealed that halloysite and montmorillonite were attacked rapidly by diluted acids, whereas kaolin, which has the same formula as halloysite, was extremely resistant to the same acids. It has been established that halloysite and montmorillonite have an amorphous form, while kaolin is crystalline. Viewing these characteristics in the light of the foregoing Frey, Yovanovitch, and Burghelle believe that this is the reason for the different behavior of diluted acids on the above-mentioned minerals.

Hofman, Endel, and Will[3] have examined bleaching clays with the aid of X-rays. According to their findings, all good sorts of bleaching clays possess the atomic structure of montmorillonite; therefore, they believe that montmorillonite is the chief constituent of fuller's earth, and activable argillaceous earths. Montmorillonite possesses according to these investigators a crystalline and lamellar structure, their chemical affinities being saturated in each lamella, which also are held together by intermediary molecular forces. This is the reason crystallization of the montmorillonite occurs vertically on the surface of the lamella. Each lamella is a complex of two layers: a layer of aluminum hydroxide, the second layer being the oxide of silica.

Vernadsky[4] believes that kaolin is an acid of aluminum and silicon $H_2Al_2Si_2O_8$, in which the oxyhydrates are directly combined with aluminum. From these considerations the formula of kaolin may be expressed as follows: $\frac{OH}{OH}>Al_2Si_2O_6.H_2O$. The complex acid $Al_2Si_2O_7$ going into reaction with the bases R_2O, forms a compound, named by Vernadsky "Kaolinic kernel," which remains intact during the further chemical reactions.

As opposed to that, montmorillonite has quite other characteristics. It does not take part in the formation of the "kaolinic kernel," but appears to be bound loosely with silicon dioxide. According to the conception of Vernadsky, the investigators, Frey, Yovanovitch, and Burghelle, conclude that montmorillonite is nothing more than a true silicate of aluminum that easily can be attacked by acids like silicates of copper and zinc. Thus, montmorillonite can be considered as a tetrametasilicate acid of aluminum of the formula $H_2Si_4O_{12}Al_2$, or better as a tetra-mesosilicate hydrate of aluminum, $Si_4O_{11}Al_2.H_2O$, since its water of constitution disappears at a temperature of approximately 700-800 deg. centigrade.

As stated, the natural bleaching clays with developed montmorillonite structure are called fuller's earth. Analysis of different types of fuller's earth vary so greatly that the chemical analyses are now well understood to be no criterion whatever in determining whether or not a particular clay shall be classified as a fuller's earth. But it is safe to say that the more the content of SiO_2 in the structure, the better will the earth decolorize. Gurwitsch gives the following tabulation of the general chemical composition of the Florida clays or fuller's earths:[5]

	Percent
SiO_2	44-72.0
Al_2O_3	5-33.0
Fe_2O_3	1-15.0
CaO	0.3-7.4
MgO	0.4-4.3
K_2O and Na_2O	0.4-8.3
H_2O	4.3-25.0
P_2O_5, SO_3, etc.	small quantities

According to the analysis of J. Th. Porter,[6] the best fuller's earths contain more than 50 percent of SiO_2. The following table shows these analyses:

Origin of the fuller's earth	SiO_2 Percent	Al_2O_3 Percent	Fe_2O_3 Percent	CaO Percent	MgO Percent	H_2O Percent
Arkansas	63.19	18.76	7.05	2.46	2.46	7.57
Florida	67.31	11.07	2.61	2.6	3.32	8.25
Georgia	72.00	10.76	7.05	3.3	4.36	6.00
Oklahoma	50.36	33.38	3.31	.....	.....	12.00
South Dakota	63.50	14.97	4.48	2.4	2.88	10.70
Woburn, England/blue	60.90	18.34	10.22	2.4	1.52	4.89
Woburn, England/yellow	55.48	19.16	11.78	3.1	3.71	6.75
Hutfield, England/blue	52.81	6.92	3.78	7.4	2.27	14.27
Hutfield, England/yellow	59.37	11.82	6.27	6.17	2.09	13.19
Reigate, England	53.00	10.00	9.75	0.5	1.25	24.00

It can be seen that bleaching clays differ greatly in their constituents. They also may contain chlorides, sulphates, carbonates, phosphates, etc., as well as moisture. The moisture content is variable, but it may be important for the development of the maximum efficiency for certain oils. The presence of relatively large amounts of lime and magnesia may lower the decolorizing power of clays, but this effect is due mainly to the neutralization of acids and to the inertness as decolorents of the lime and magnesia themselves.

The interior structure of bleaching clays plays the most important part in their classification. In other words, it can be said that the montmorillonite content influences the classification of bleaching clays.

The writer also has studied this problem, and has observed that the content of montmorillonite is insufficient for a classification of an earth. As indicated, the weathering process of feldspar led to a splitting up into two new combinations in such a manner that the part insoluble in water formed a structure with microscopic channels, these channels being filled with the second part, or that soluble in water. It has been found by the writer that the structure of the microscopic channels shows a crystalline structure of montmorillonite. In case these channels are not empty, however, i.e., that these channels are filled with a water-soluble silicate, the microscopic channels are not able to decolorize oils or paraffin waxes.

In nature this water-soluble part is slowly removed by the action of water and carbonic acid, resulting in the formation of a very porous fuller's earth. Of course, the larger the quantities of water-soluble silicates removed the greater is the adsorptive power of the natural bleaching clay. In other words, adsorption depends greatly upon the number of empty channels, i.e., upon the adsorption surface. It can be seen that the weathering process resulted in the formation of many sorts of fuller's earth, their activity being dependent

upon the amount of the emptied microscopic channels. However, there are to be found many natural bleaching clays with the montmorillonite structure, that are filled partly or entirely with water-soluble silicates. These earths therefore must be submitted to an artificial leaching process, in which the water-soluble silicates are removed. This is accomplished by various methods, which will be discussed in a subsequent article.

Let us now consider the chemical composition and the characteristics of the third type of bleaching clay, the so-called bauxite. This mineral was discovered by Bertier 50 years ago. It contains aluminum oxide as the chief constituent. An analysis of two kinds of bauxite from Spain, conducted by the writer, showed the following components:

	I. Percent	II. Percent
Al_2O_3	59.6	52.2
Fe_2O_3	1.2	25.2
TiO_2	4.3	.....
SiO_2	14.3	2.2
H_2O	20.6	20.4

The chief characteristic of bauxite is the chemical affinity for gaseous and liquid compounds of sulphur. According to the writer's investigations, the desulphurization of oils with the aid of bauxite is a function of its exterior surface, i.e., the desulphurization decreases with the fineness of the bauxite. The action decreases entirely when exceeding the maximum of fineness. The reason for this is the closing of the narrow and long microscopic channels by the sulphur compounds, thus lowering the whole sphere of action; furthermore, water content plays a very important part in the desulphurization of oils. The more water a bauxite contains the more difficult is the desulphurization of oils. The reason for this is that the water, being on the exterior surface of bauxite molecules, decreases its active zone of field, therefore, the bauxite first must be dehydrated. This is done by so-called calcination, i. e., by a proper heating of the bauxite. The temperature usually is 400 deg. centrigrade. Many investigators maintain that the temperature of 600 deg. centigrade increases the desulphurization.

It can be seen from the foregoing that the mineral bleaching clay may be divided into three types:

1. Fuller's earth with the developed montmorillonite structure, their microscopic channels being partly filled with other silicates. In this instance the action of diluted or weak acids leaches the rest of these inhibitors.

2. Inactive bleaching clay, as bentonite, etc., with the developed montmorillonite structure, their microscopic channels being entirely filled with other silicates. In this instance a leaching process must be carried out by means of concentric and strong acid.

3. Bauxite, whose exterior surface causes a desulphurization and decoloration of oils. Since the water content weakens the sphere of action, a calcination at the temperature 400-600 deg. cent. much be carried out. Exceeding this temperature destroys the desulphurization power. The reason for this is the splitting up of the aluminum and iron oxides.

Literature Cited

[1]French patent, 641,147.

[2]Protectorat de la Republique Francaise. Notes et Memoires, 1936. No. 38.

[3]Zeitschrift fur angew. Chemie, 1934, p. 50; 1935, p. 188.

[4]La geochemie, Paris, 1914, pp. 154 and 165.

[5]Scientific principles of Petroleum Technology. London, 1926.

[6]Contribution to Economic Geology, Part I, 1906, pp. 268-290.

Bureau of Mines Reports on Oklahoma City Oil Field

APPROXIMATELY 339,000,000 bbl. of oil were recovered from all zones of the Oklahoma City oil field to October 1, 1936, according to an engineering report on the field, just issued by the U. S. Bureau of Mines, Department of the Interior. This field, the history of which has been associated closely with rules and regulations pertaining to production control and proration practices, was the first major oil field in which the producing wells were more than a mile deep. The rapid development of the field and the great depth of the wells, together with the high gas pressure, required the development of many new procedures and special items of equipment.

Not only were the wells in the Oklahoma City field deep and the reservoir pressures high, but the early wells produced oil of light A.P.I. gravity accompanied by large volumes of gas. Several "blowouts" and fires occurred during the early development, and the close proximity of these now unusual events to a city of nearly 200,000 inhabitants gave the field much local publicity that spread rapidly throughout the reading world. Later, when the production from the field threatened to demoralize the market for oil and its products, the Oklahoma City field received much additional publicity, and during the latter part of 1935 it came to nation-wide attention again when it was extended in a northerly direction to include the State Capitol grounds and the Governor's Mansion.

The report discusses problems involved in the field's development and operation during a period of about eight years, as well as rules and regulations pertaining to production control.

Development of the Oklahoma City field started in the Arbuckle limestone zone on the high part of the structure. The Lower Simpson zone on the flank of the Arbuckle zone was the next to be developed. As finally interpreted, the Lower Simpson zone included four sandstone members, which probably contained free gas in their "tips," or in the high parts of the pay strata where they are continuous across the structure. Perhaps the greatest surprise in the development of the Oklahoma City field was the prolific recovery from the Wilcox zone in the lowest part of the field structurally and the last area to be developed. The history of the Wilcox area centers around large wells, prolific recoveries from a relatively uniform thick sand, and problems involved in the protection and conservation of its oil and gas.

Between the completion of the discovery well in December, 1928, and October 1, 1936, 1339 producing oil and gas wells were drilled, outlining a proved area of approximately 15,000 acres. The 339,000,000 bbl. of oil recovered to October 1, 1936, is about 55 percent of the estimated ultimate recovery.

The report discusses important subjects such as reservoir conditions, gas-oil ratios, solubility and shrinkage relations, bottom-hole pressures, well spacing, and water history. Considerable emphasis is given to physical factors and their relative importance in estimating recovery values. The discussions in the text are supplemented by many tables and illustrations.

The results of a detailed engineering study of the field, dealing with the main oil-producing reservoir in the Cambro-Ordovician rocks and the gas-bearing horizons in the Pennsylvania formations, are presented in Bureau of Mines Report of Investigations 3330, Engineering Report on Oklahoma City Field, Oklahoma, by H. B. Hill, E. L. Rawlins, and C. R. Bopp, published through the coöperative assistance of the State of Oklahoma. This report containing 243 mimeographed pages and 69 illustrations is available upon request from the Information Division, U. S. Bureau of Mines, Washington, D. C., or the Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma.

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Each of the four types shown on this page has its own particular applications in which its use gives increased safety, lower costs, or both.

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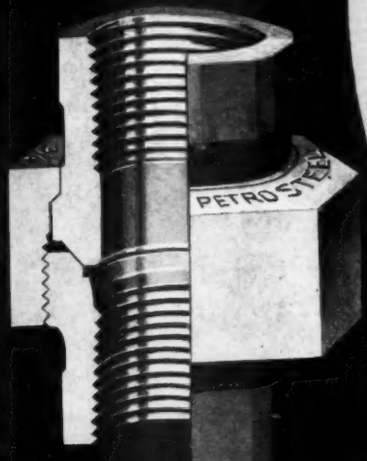

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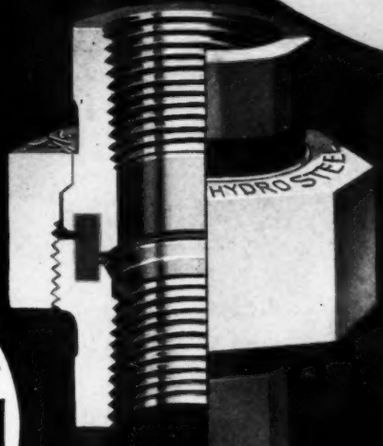

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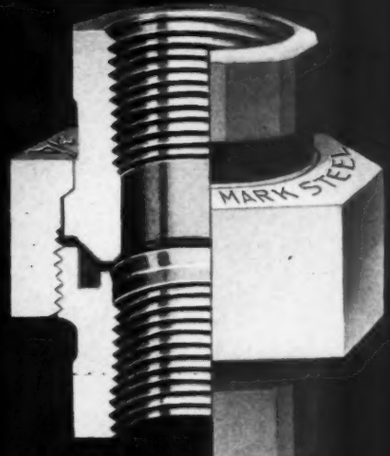
BRASS-to-BRASS SEATS

1/4" to 3"



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Firing line welders at work along Corpus Christi Bay near the end of the line. Due to the unevenness of the terrain it was necessary to line the pipe up on timbers for the making of roll welds.

Laying a Pipe Line Through "Hot" Soil of South Texas

By FRANK H. LOVE

Soil tests made over entire right-of-way to determine the type and quantities of coatings suitable to provide best protection for line laid to tidewater at Corpus Christi, Texas, by the Magnolia Pipe Line Company

PROVIDING another water outlet for crude oil from the South Texas area, the Magnolia Pipe Line Company has just completed and placed in operation an 8-in. line from its Tilden station on the Duval-McMullen County line to port at Corpus Christi. Additional pumping facilities have been made necessary at the Tilden station to handle the increased load. Heretofore crude has been pumped in but one direction, north to Luling, from where it was sent to the Magnolia's refinery at Beaumont. For this purpose two 165-hp. gas engines driving 5½ by 10 reciprocating pumps have been in use, with a capacity of 16,000 to 17,000 bbl. daily, the latter figure representing the volume pumped during summer months when the oil is less viscous. At the Tilden station has been added a 165-hp. gas engine driving a 5½ by 24 reciprocating pump, increasing capacity 13,000 bbl. daily, as well as two new 80,000 bbl. tanks.

The soil of South Texas being well known for its active corrosive properties in spots, and varying in the degree of intensity, officials of the Magnolia Pipe Line Company deemed it advisable to make soil tests over the entire right-of-way and use the type and amount of pipe coating thought suitable to give best protection. Accordingly, at the time the right-of-way was surveyed

In making highway and railroad crossings, steel straps of ½-in. thickness were welded to the line pipe in a staggered manner to protect coatings and wrappings from damage when pulled through the casing. This photograph shows a particularly long crossing, where a highway and railroad were crossed with one section of pipe. The section was 170 ft. in length.

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TULSA, OKLA., Jan. 16—The oil industry is no place for weak sisters. Equipment has to be "hard boiled" to last in the oil country. There isn't another industry in the country in which valves, fittings and piping have to take it, and like it, as they do when handling oil from the bottom of the hole to the tank on the rear of a car or to the bearings of a battleship.

That's why Crane puts so much extra strength into all its oil field products. Crane designers, Crane engineers, Crane metallurgists, all read A.P.I. and A.S.M.E. specifications in just one way. They look to see what the maximum requirements are—and then they better them in finished Crane products.

More than that, Crane is always anticipating oil country, pipe line and refinery needs. Valves and fittings are constantly being designed to handle temperatures and pressures not used at present. They are tortured in every conceivable way to test them in the laboratory—then they are spotted around the country in tough services and given "the works." That's how accepted Crane designs originate. Crane is ready for oil country demands in proven territories, in wildcats that need taming and in all refining services.

Pack Your Problems Off to Crane

If there is some "hot spot" making trouble in your lines or on your equipment, give us a chance to look it over. There may be a piece of regular CranEquipment that will do the job. Or it may require special treatment. Anyway, ask Crane about it. We can give you the answer if anyone can.

"Ragging on" hot coating in the conventional manner.

tests were made at regular intervals with a Sheppard cane to determine the resistance of the soil. These readings were taken approximately every 200 ft., sometimes at shorter distances when external indications pointed to a possible change in the condition of the soil. Soil samples were procured at pipe depth approximately every quarter of a mile, obtained by means of a hand auger, after which the soil resistance was determined at the bottom of the hole thus left by the removal of the soil sample, to check with the first reading. The soil samples were tested in the field laboratory for the degree of acidity or alkalinity, the saturated resistance was measure, and a Corfield nipple test conducted. For measuring the alkalinity or acidity of the soil a p^H electrometer was employed, and for determining the saturated resistance, a Wheatstone bridge.

In making the Corfield test, nipples ¾ in. in diameter and 4 in. in length were cut from standard pipe. These were ground and buffed to remove all mill scale, then numbered, and weighed. Each nipple was placed vertically in a pint can, a rubber stopper first being placed in the lower end of the nipple to insulate it from the container. Around the nipple was packed the saturated soil sample. The test cans were placed in a rack and a 6-volt battery connected across from the pipe to the can, the pipe being positive. After leaving in circuit for 24 hours the nipples were removed and cleaned before again being weighed. The loss in weight was recorded as well as the type of action on the nipple. From these data the amount and type of protective covering for given areas were determined.

Four kinds of coatings were applied: (1) a primer coating of light-weight paint with a second coating of heavier paint, both having an asphalt base; (2) applications of light and heavy paint, a wrapper, followed by a second coating of heavy paint, another wrapper, followed by a second coating of heavy paint; (3) light and heavy paint, wrapper, heavy paint, another wrapper, and heavy paint; (4) liquid grease primer, followed by a heavy grease, fabric wrapper, grease, an asbestos wrapper, a hot coating consisting of asphalt and wax mixture, and finally a wrapping of Kraft paper. This latter combination was used in the most corrosive soils. The grease applications were made by hand, the paint coatings as well as the hot enamel were "ragged on" in the conventional manner, and all wrappers were applied to the pipe spirally by hand.

Viewing the line as a whole, the most corrosive conditions were encountered on the east end, near Corpus Christi. Here the line passes through the Saxet oilfield where slush pits and various conditions add to the corrosiveness of the soil. Irrigated lands in this vicinity, too, were found to be extremely "hot". Elsewhere along the right-of-way the types of soil encountered were sand, crumbly limestone, volcanic ash, a black waxey soil, and a small amount of clay.

Line pipe used in construction was reconditioned stock laid in 1930 between Depew and Burbank, Oklahoma. It was taken up and cut into joints averaging 30 ft. in length. The pipe was in good condition when removed from the ground and required but little reconditioning other than the cutting out of certain bad sections, and a small amount of spot welding. The pipe was shipped to various points in

Grease coating was applied by hand as shown here.

In the "hottest" soils the pipe was covered with a liquid grease primer, followed by a heavy grease, a fabric wrapper, another coating of grease, an asbestos wrapper, a hot coating consisting of asphalt and grease mixture, and a wrapping of Kraft paper. All of these have been applied to the pipe shown in this photograph, which is on skids above the ditch awaiting the lowering-in gang.

South Texas along the route of the line —San Diego, Alice, Viola, Nueces, and Calallen—and was strung with the use of trucks equipped with winches. The first 30 miles of the right-of-way was devoid of roads, making it necessary for the trucks to traverse ranches, much of the land being grown over with cactus and brush; however, the terrain was level and little difficulty was experienced in stringing.

A trench averaging 30 in. in depth and 20 in. in width was cut by a conventional type ditching machine. Slag was allowed to fall back into the bottom of the ditch to provide a cushion for the pipe to rest upon. With the land level, and the soil easily cut, the two ditchers were able to make virtually any desired amount of trench a day, but were limited to 8,000 to 10,000 ft. so that they would not get too far ahead of the "dope" gangs and thus leave an excessive amount of open ditch. In but one spot, approximately 20 miles from the Tilden station, was sufficient rock encountered to necessitate blasting. Several arroyos were crossed; however, except for one instance they were shallow enough for the ditcher to traverse; in the one instance the ditch had to be dug by hand.

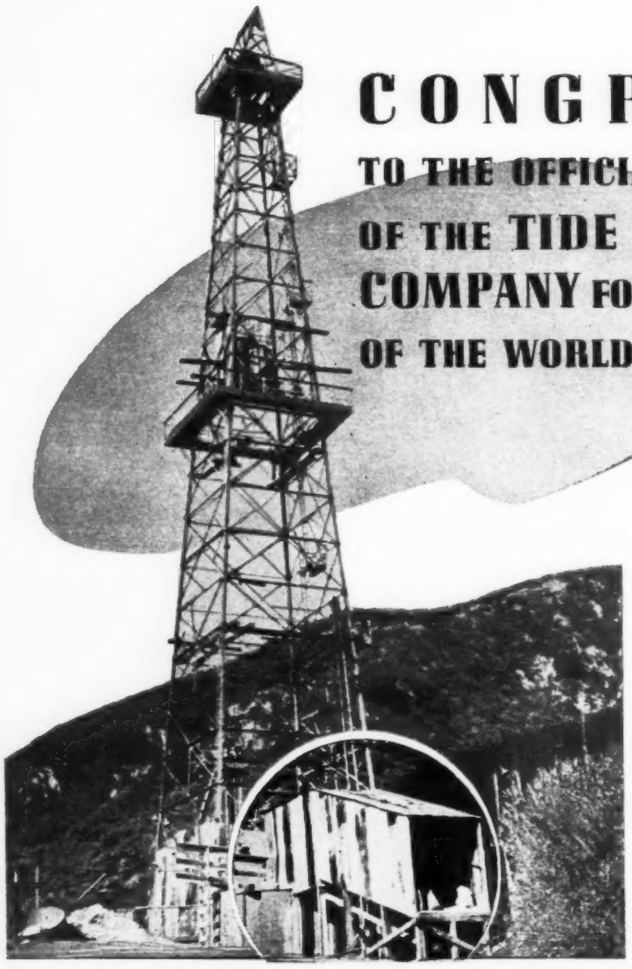
Tack welds, roll welds, and tie-ins were all made by the electric method. The pipe was lined up on dollies by means of tractors equipped with winches. Each of the two gangs employed seven welding machines, and, in addition, one unit mounted on a truck was used as a "run around machine" for putting in and cutting out slack, cutting down creek crossings, welding road casings, etc. As is usual procedure, following the lineup gang came the tack welders, then the roll welders, and finally the bell-hole welders. Straight 8-in. butt welds were made. For the stringer bead $\frac{3}{16}$-in. electrodes were used, for the second bead $\frac{1}{4}$-in., and for the finish bead $\frac{5}{16}$-in. electrodes. Each firing-line welder averaged 45 welds per 8-hour day, and each bell-hole welder on an average made 30 a day. The joints of pipe were welded into sections of approximately 280 ft. length.

After being welded and coated the pipe was lifted from the skids, upon which they had been placed above the ditch, and lowered in, tripods equipped with ratchets being employed for the purpose, three tripods to each gang. Slack loops were left every 1000 ft., to be lowered in in the early morning when the pipe was cold and contraction maximum. Two backfillers followed each lowering-in gang, covering daily as much pipe as was placed in the ditch.

Gate valves were not spaced at any regular interval, rather where they were most needed, on the pressure side of each railroad crossing. Over the entire length of the line but three were required, near Robstown, Alice, and at Nueces Switch. At all such railroad crossings the pipe was run through 10-in. casing, the space between the line pipe and the casing being sealed with concrete at either end. The railroad crossings also were vented. In making highway crossings the same procedure was followed, except that the casing was not vented. At highway and railroad crossings, in order to protect coatings and wrappings from damage, steel straps of $\frac{1}{2}$-in. thickness were welded to the pipe in a staggered manner, being placed approximately every five ft. on the bottom side and ever nine ft. on top. These straps, extending above the coating and wrapping, served as protection when the pipe was being pulled through the casing.

At Corpus Christi the crude is being loaded on tankers for shipment abroad. At present Magnolia has an arrangement with The Texas Company for the use of the latter's loading dock. Later the company may construct a dock of its own.

Close-up of one of the welders making a roll weld by the electric method.



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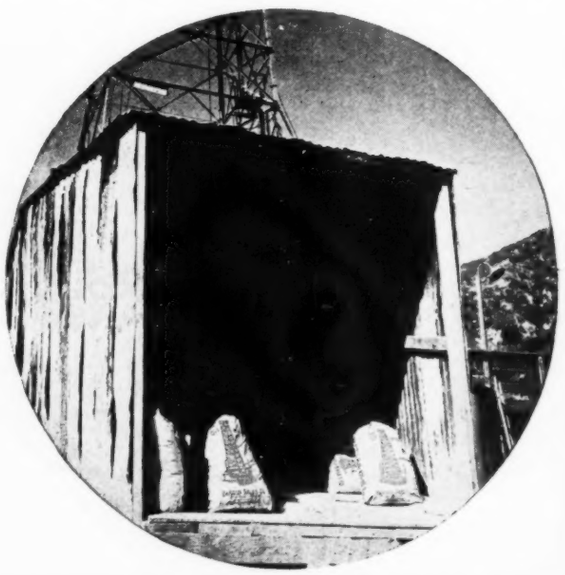

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Geophysics—Its Application To Petroleum Prospecting*

By
DR. J. BRIAN EBY

This is a story of geophysics presenting an outline of the development and principles of geophysics, geophysical methods and equipment, and their applications to modern petroleum prospecting

THE story of the search for the minerals of the earth begins before the first pages of history were written. Prehistoric man roamed far and wide to find a bigger and sharper piece of flint than his neighbor, to place in his stone axe. Ancient man used iron and copper and fashioned it crudely into weapons or implements. The records of early China and Japan are reported to mention the use of natural gas. The Bible has several passages on the use of pitch (bitumen or oil). The Assyrians, Egyptians, Greeks, and Romans explored for, mined, and used several of the more common metals.

Gold has been the metal of greatest esteem or value of nearly every great civilization and the search for it, its exploitation and possession, probably has affected the rise and fall of more empires than any other single cause. Pizarro went to Peru and Cortez to Mexico in the search for gold. They probably had more faith in the services of their blunderbuss and sword than in their pick and shovel, in the quest of the precious metal. The favored tools of mineral exploration at that time were the battle-axe and cannon.

Today, even to the most disinterested spectator, it must not fail to be a constant source of fascination to see a great oil field arise from a featureless grassy marshland. Within recent years in coastal Louisiana, Texas, and several foreign coastal countries, many prolific oil fields have been discovered where not one single iota of surface indication hinted at their presence. The magic that brought these fields to light belongs to none of the time-honored methods of the hard-rock geologist, with the hand lens, pick, and hammer.

The story behind these discoveries goes far afield from the customary haunts of the geologist. It takes one into the realms of mathematics, physics, astronomy, and more especially the branches of gravity, electricity, seismology, and magnetism. It involves many of the best scientists of America, England, Germany, France, Hungary, Russia, and numerous other countries. It involves the foundation of a new science, the science of applied geophysics.

This science deals with the measurement of various physical properties of the rocks of the earth, both on and below the surface. As these properties exhibit differences from place to place, due to difference in depth of the rocks, or to structural displacement or changes in the rock texture or hardness, any means of detecting and recording these minute differences will tell something of the actual subsurface structure of the rocks themselves. The ever-increasing demands of industry for the minerals of the earth, principally oil, the competitive zeal of exploration and producing companies, and some brilliant scientific thinking, brought geophysics into being as a practical aid to geology in mineral exploration.

Geology itself is a comparatively youthful science. The founders of the science, among the most illustrious of whom are Sir Roderick Murchison and Sir Charles Lyell of England, Abraham Gottlieb Werner, father of German geology, Sir Archibald Geikie, of Scotland, and James Hall of New York State, all lived between 1750 and 1900. The first serious commercial application of geology followed Drake's discovery of oil in Pennsylvania in 1859 and the immediate phenomenal rise of the oil business. The announcement of the "anticlinal theory" of oil accumulation, in 1882[1] by Dr. I. C. White, State Geologist of West Virginia, laid the real cornerstone of petroleum geology.

J. Brian Eby's education and experience fit him to write authoritatively on the subject of geophysics as applied to petroleum prospecting. He was graduated from Johns Hopkins University in 1918 with the degree of A.B., and in 1922 received a degree of Ph.D. in geology from the same institution. From 1919 to 1925 he was geologist with the United States Geological Survey, being stationed variously at Washington, D. C., in the Appalachian and in the Rocky Mountain states. He was in charge of the Geophysical Department of the Gulf Coast Division of the Shell Petroleum Corporation from 1925 to 1931, and since has been an independent geologist, making his headquarters at Houston, Texas.

*It is the purpose of this article to present a few of the more interesting and pertinent facts concerning the origin and use of geophysics in the exploration for the earth's minerals, especially that of oil. It is written from the point of view of a geologist interested in geophysics rather than an attempt to present a mathematical or physical discussion. Many of the data in this paper are gathered from published articles, many references to which are given, but complete geophysical bibliographies are available in many of the college or technical libraries. The writer expresses his appreciation for the permission of Dr. Donald C. Barton, geologist and geophysicist of Houston, Texas, to read the advance manuscript of two papers by him entitled "Gravitational Methods of Prospecting for Petroleum" and "Petroleum Geophysics" both in the course of publication by the Oxford University Press, London, England, in "The Science of Petroleum."

Briefly, the anticlinal theory states that if oil and gas and water occur in bedded sands or sandstone and the formation is uplifted into a closed upfold, anticline, or dome, the oil, gas, and water will accumulate in distinct horizons in the sand body according to the specific gravity of each. This will tend to permit the oil to segregate itself in commercially recoverable quantities. Drilling quickly proved the wisdom of the theory and hence the search for new oil fields developed into a search for new (undrilled) anticlines. For this purpose the geologist used his familiar pick, hammer, and lens to examine the rocks in the field, and the compass, alidade, plane table, and aneroid barometer to place this information on a map. Such at least were the tools of the oil geologist down to about 1922.

Back in 1901, however, on January 10th, to be exact, there occurred a momentous event in the history of petroleum exploration. Captain Lucas, drilling a wildcat well near Beaumont, Texas, brought in a gusher, which ushered in the now world-famous Spindletop oil field. On the broad surface of the Gulf Coast, for a hundred thousand square miles, not a single solid rock outcropped at the surface. The Appalachian and Rocky Mountain geologists who journeyed to Spindletop at the dawn of the twentieth century must have trembled at the prospect of finding and mapping anticlines on the vast stretches of the lowland coast.

They found at Spindletop, however, some topographic mounding, caused, as discovered later, by the uplifting of a buried salt plug or dome. In lieu of "hard-rock" geology, the coastal geologic criteria for new prospects became topographic mounding, oil or gas seeps, mineralized waters, and deflected stream patterns. For 20 years these criteria prevailed but actual oil field discoveries became fewer and fewer, (see Fig. 1). Drilling became a hazard and the way of the geologist was difficult indeed.

The North German salt dome basin, the lowlands of Venezuela, the coast of Mexico, and the stretches of the Russian Emba desert present the same problem. The oil-bearing structures are buried by overlying flat rock strata or covered by wind-blown sand or recent alluvium. The actual oil structure could be found only by drilling, and the chance of hitting it by wildcat location was an extremely remote one. Until the advent of geophysics there was no method for determining the location of such subsurface structures, where all surface indications were lacking. It was in these regions that geophysics played such an extraordinary role, a revelation to the geologist, a boon to the oil business, and to the public, a mysterious thing.

Geophysical methods group themselves naturally into those that deal with gravity, with seismic velocities, with earth magnetism, with electrical measurements, with radioactive emanations, and lesser known and used processes. The torsion balance is the principal instrument in gravity work, but the gravitimeter, and pendulum, also come in this category. The refraction and reflection seismographs measure the speed and character of artificially-excited earth waves through various rocks. The magnetometer records the variations in the earth's magnetic field brought about by local magnetic anomalies.

THE TORSION BALANCE

Oil company executives, geologists, and others, from time to time have had placed before them a torsion balance prospect map. On this map appeared many arrows, called "gradients," pointing either towards or away from some general common center. The legend stated the arrows were measured by units known as "eotvos," and that so many eotvos were represented by certain parts of an inch. If the gradients pointed inward the feature was labeled a "maximum," if outward, a "minimum." See Figs. 2, 3 and 4. These arrows or gradients (as described later) represent graphically the amount and direction of the rate of the change of gravity. The relation of these minute gravity differences to

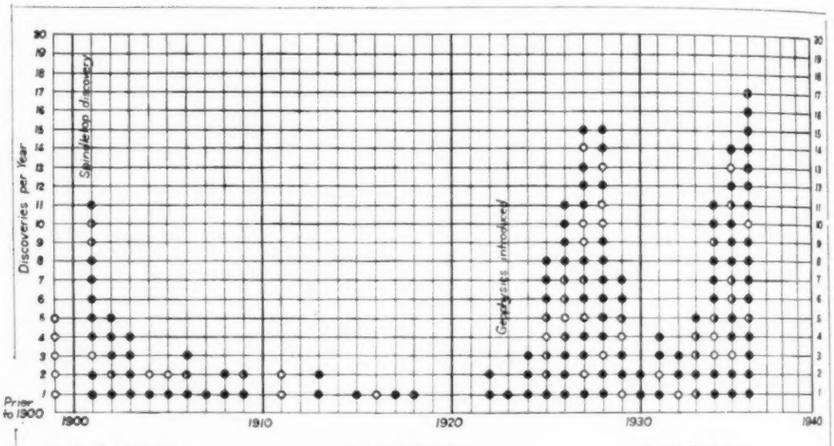


Fig. 1. Chronology of Dome and Oil Field Discoveries on Gulf Coast

NOTE: *Names as listed below correspond to symbols reading up.*

Prior to 1900
Belle Isle
Cote Blanche
Weeks Island
Avery Island
Jefferson Island

1901
Spindletop
Damon Mound
Bryan Heights
West Columbia
High Island
Hackberry
Saratoga
Pierce Junction
Big Hill—Jeff.
Big Hill—Mat.
Jennings

1902
Barbers Hill
Piedras Pintas
Sour Lake
South Liberty
Vinton

1903
Batson
Sulphur
Welsh
Blue Ridge

1904
North Dayton
Hoskins Mound

1905
Humble
Davis Hill

1906
Goose Creek
Hockley
Bayou Bouillion

1907
Anse La Butte

1908
Hull
Markham

1909
Edgerly
Pine Prairie

1911
Houma
Gyp Hill

1913
Orange
Stratton Ridge

1915
Brenham

1916
Palangana

1917
New Iberia

1918
Section Twenty Eight

1922
Big Creek
Lockport

1923
Boling

1924
Nash
Orchard
Long Point

1925
Roanoke
Sweet Lake
Clemens
Allen
Hawkinsville
Fannett
Starks
Arriola

1926
Clay Creek
Bayou Blue
Sorrento
Moss Bluff
Napoleonville
Fausse Point
Bayou Des Glaise
White Castle
Port Barre
Bayou Choctaw
East Hackberry

1927
Raccoon Bend
Alta Verde
Hankamer
Sugarland
Chacahoula
Darrow
Brookshire
Lost Lake
Calcasieu Lake
Vermilion Bay
Dog Lake
Black Bayou
Four Isle
East Bayou Junop
Bay St. Elaine

1928
Garden Island Bay
Louise
Genoa
Esperson
Mykawa
Lake Washington
Caillou Island
Lake Pelto
Lake Barre
Lake Salvador
Venice
Leesville
Potash
Port Neches
Lake Hermitage

1929
Needville
Manvel
Iowa
Fergusons Crossing
Danbury
Cameron Meadows
Gueydan

1930
Sheppards Mott
East Stratton Ridge

1931
Rabb Ridge
Minor Estate
Buckeye
Conroe

1932
Spurger
Pledger
Livingston

1933
Ace
Tomball
Garwood
LaRose (Valentine)
Cleveland

1934
VanVleck
Bosco
Splendora
Citrus Grove
Vanderbilt
Kittrell
Gillis-English Bayou
Old Ocean
Eureka
Dickinson
Hastings

1935
Anahuac
LaFitte
Katy
South Houston
Pickett Ridge
Mauritz (Midfield)
Hardin
Tepetate
Withers
Turtle Bay
Saint Martinsville
Chaneyville
Big Lake
Jeanerette

1936
Bayou Mallet
Amelia
Bay City
Lochridge
Greens Lake
Fairbanks (Satsuma)
Nome
Cotton Lake
Lake Mongoulois
Convent (Hester)
Charenton
Seabreeze
Clinton
Silsbee
Segno
Magnet
South Jennings

[1]Published three years later in *"Science,"* June 26, 1885.

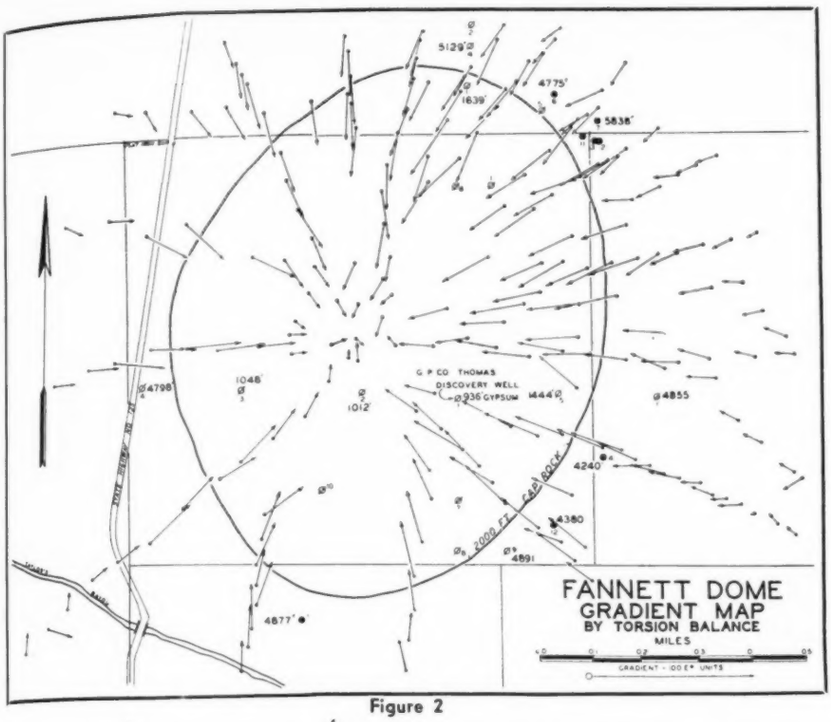


Figure 2

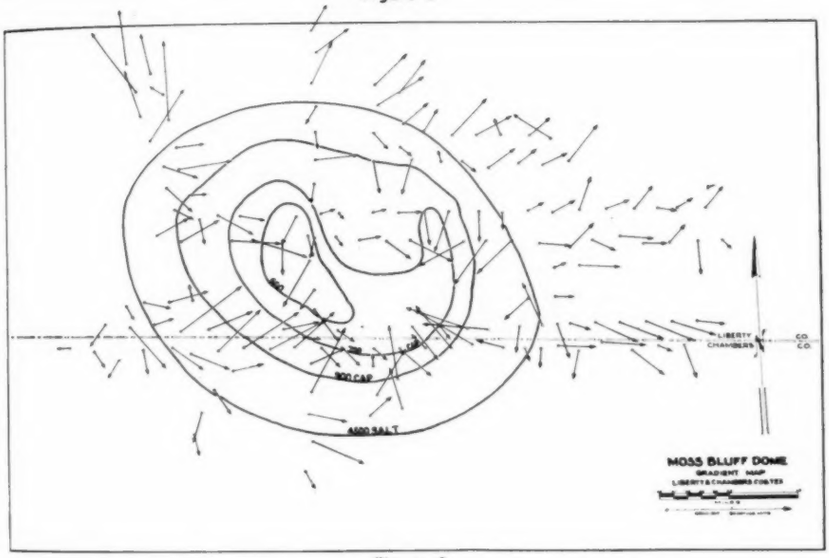


Figure 3

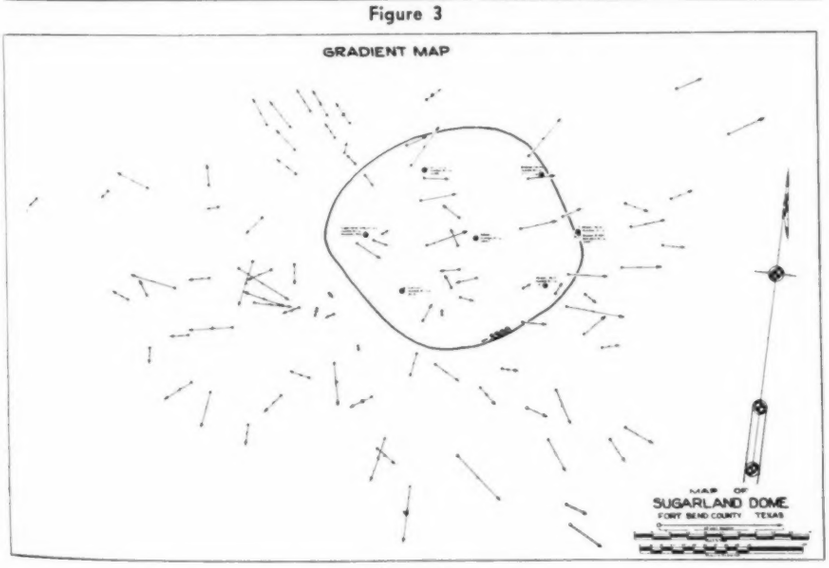


Figure 4

Fig. 2. Torsion balance map of the Fannett Dome, Jefferson County, Texas, showing a "maximum" picture. (See "Geophysics of Salt Dome Structures" Bulletin of Am. Association Pet. Geol. Vol. 19, March, 1935, Fig. 5, page 362.)

Fig. 3. Torsion balance map of Moss Bluff Dome, Liberty and Chambers counties, Texas, showing a "maximum" picture on the shallow cap rock and a "minimum" picture for the main body of the salt. (See "Geophysics of Salt Dome Structures" Bulletin of Am. Association Pet. Geol. Vol. 19, March, 1935, Fig. 2, page 359.)

Fig. 4. Torsion balance map of the Sugarland Dome, Fort Bend County, Texas, showing principally the "minimum" effect of the salt mass. (See "Geophysics of Salt Dome Structures" Bulletin of Am. Association Pet. Geol. Vol. 19, March, 1935, Fig. 9, page 367.)

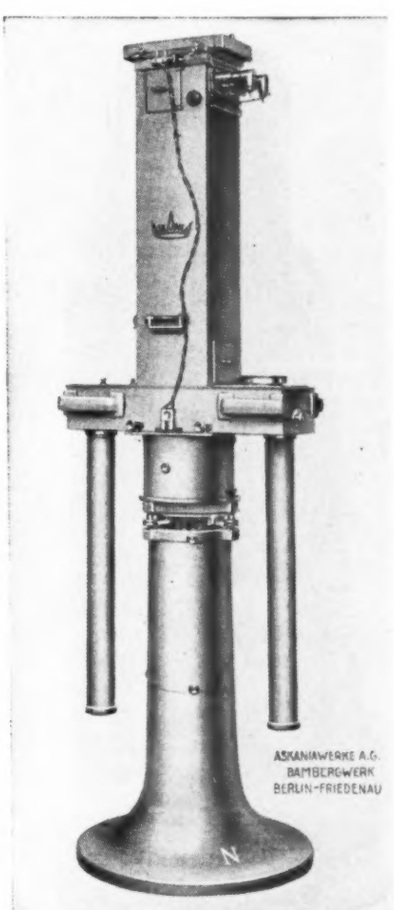


Fig. 5. Photograph of the large type torison balance. (Courtesy of American Askania Corporation.)

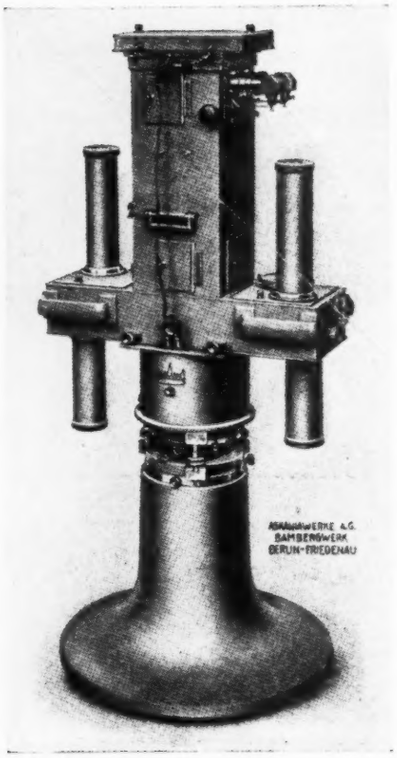


Fig. 6. Photograph of the small "Z-Bar" type torsion balance. (See American Askania Corporation pamphlet, Geo. 103 E.)

geologic structure makes necessary first a few words about gravity itself.

Almost two and one-half centuries ago, history states that Sir Isaac Newton, in observing the fact that an apple fell to the earth, derived the first inspiration that led to his famous law of gravity; namely, that any two bodies attract each other directly in proportion to their masses and inversely as the square of the distance between them. The simple experiment of suspending by fine wires two balls, in close proximity, permits one to observe that both balls by their mutual attraction will be pulled towards each other and therefore both will be out of plumb. If the one ball is lead and the other ivory, the lead ball will pull the ivory ball farther out of plumb than it will be itself. This is a simple demonstration of the principle of attraction between any two bodies of different masses.

Gravity on the surface of the earth is felt as an attraction or force holding or pulling a body or mass towards the earth's center. The effect or pull of gravity decreases upwards; that is, away from the earth's center. Because of the fact that the earth is slightly flattened at the poles and considering the earth's rotation (centrifugal force) the influence of gravity is greater at the poles than at the equator. There is therefore, a definite and progressive difference in gravity in the horizontal plane in a north-south direction.

It is customary to express the force of gravity at the equator as 978 (cm/sec.^{2}) units and at the poles as 983 (cm/sec.^{2}) units, a difference of five units. The distance from equator to pole is about 10,000 km. (one km. equals 3280 ft.), which reduced to cm. (one cm. equals .3937 of an in.) is one thousand million (the American billion) or 10^9 centimeters. Since, therefore, there is a gravity change of five units in the 10^9 cm. distance from equator to pole, the exact change for each cm. (4/10ths of an in.) of distance is five divided by 10^9, which is expressed as 5×10^{-9}.

The units of measurement used in applied gravity prospecting are the "milligal" and the "eötvös." The milligal is the unit of measurement of the intensity of gravity represented, 0.001 cm/sec.^{2} and is about the millionth part of gravity at sea-level. The eötvos is the unit of measurement of the gradiant or variation of gravity per centimeter and is represented, 1×10^{-9} gal. per cm., (cm/sec.^{2}/cm.), which is approximately the change of one million millionth of gravity at sea-level per horizontal centimeter of

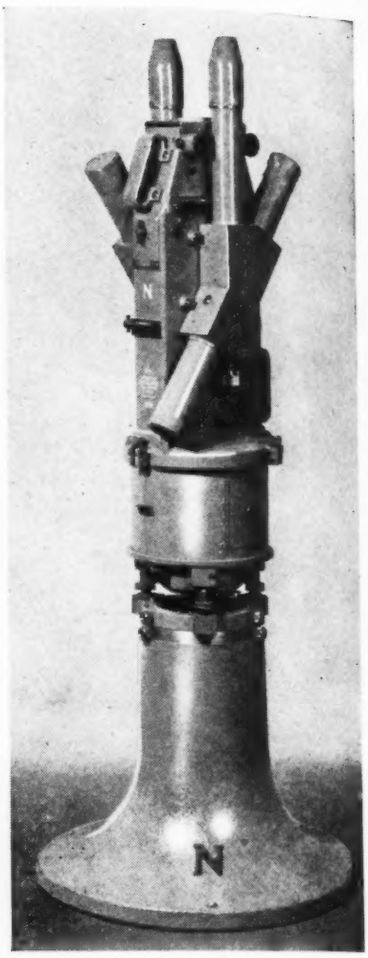


Fig. 7. New inclined beam torsion balance for automatic operation. This instrument reduces the time for making a complete observation in the field from about four to five hours down to approximately an hour and a half. Complete description of this instrument is given in the pamphlet, Geo. 120 E. of the American Askania Corporation, Houston, Texas.

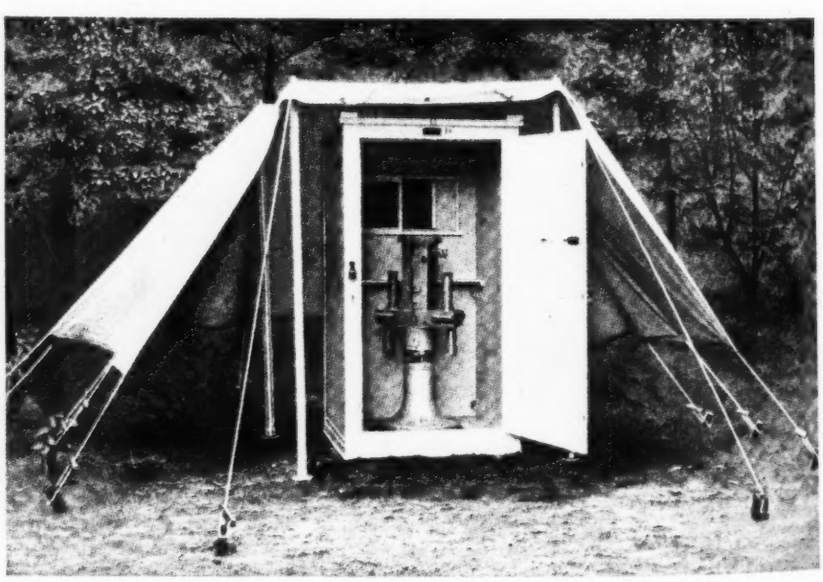


Fig. 8. Small "Z-Bar" type torsion balance in position in the field, showing also the field hut used to insulate the instrument from weather and temperature changes and also a canvas fly sometimes used for additional protection.

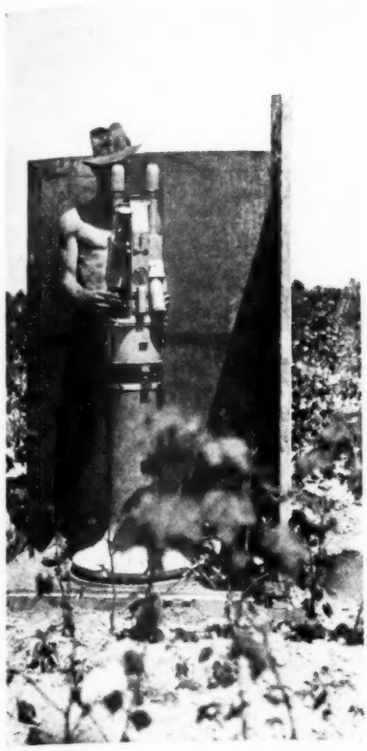


Fig. 9. Set up in the field one of the newest type short period torsion balances.

distance. The gradient, therefore, as plotted on the ordinary torsion balance map, is a vector or arrow directed towards the maximum increase in gravity. The amount of the increase is expressed by the number of eotvos units, which are usually plotted one millimeter to one eotvos.

The torsion balance has an accuracy of one eötvos, which means that if gravity changes but one million millionth in a distance of only one cm. (4/10ths of an in.) the torsion balance will measure it. This is an inconceivably small quantity. By comparison, gravity decreases upwards more rapidly than it changes in a horizontal plane. This means that to bring about the same change in gravity in a vertical direction as the effect of one eötvos in a four-tenth of an inch in a horizontal distance, the vertical distance need be only about the thickness of an ordinary sheet of paper.

The torsion balance, as used today, was invented in principle and first constructed by Baron Roland v. Eötvös, professor at the University of Budapest. His earliest publication on the subject appeared under the title of "Investigations on Gravity and Earth Magnetic Force" in Wiedemanns Annalen, 1896. Following this he experimented several years for the Hungarian government with his new balance. His paper entitled "Determination of the Gravitational Gradients and Planes by Aid of the Torsion Balance," which he presented before the 15th general conference on International Geodesy at Budapest in 1906, and which was published in the proceedings of this Congress, was first to draw widespread attention to his discovery, but no commercial use was made of it at the time.

Long before the time of Eötvös a torsion balance was known. This early balance was known as the Coulomb balance and consisted merely of a horizontal bar with weights at each end and this system suspended by a long fine wire. The two weights of the balance are at opposite ends of the horizontal beam, and the instrument, therefore, can measure only one of the two quantities, the differential curvature, which are measured by the Eötvös torsion balance, and does not measure the gradient, which is the one mainly used in gravitational prospecting. The differential curvature tells something of how level surfaces are warped. The surface of a large body of water at rest is a level surface. The ocean surface is level but conforms to the curvature of the earth. To the torsion balance a level surface is not a flat plane but is curved and the torsion balance, both the old Coulomb (or Cavendish) torsion balance and the modern Eötvös torsion balance, measure

Fig. 10. An explosion of approximately 500 lb. of dynamite in the black land section of the Gulf Coast in the vicinity of Houston.

Fig. 11. An explosion of about 500 lb. of dynamite in the sandy soil of the Rio Grande Valley section.

Fig. 12. A typical water shot of approximately 500 lb. of dynamite.

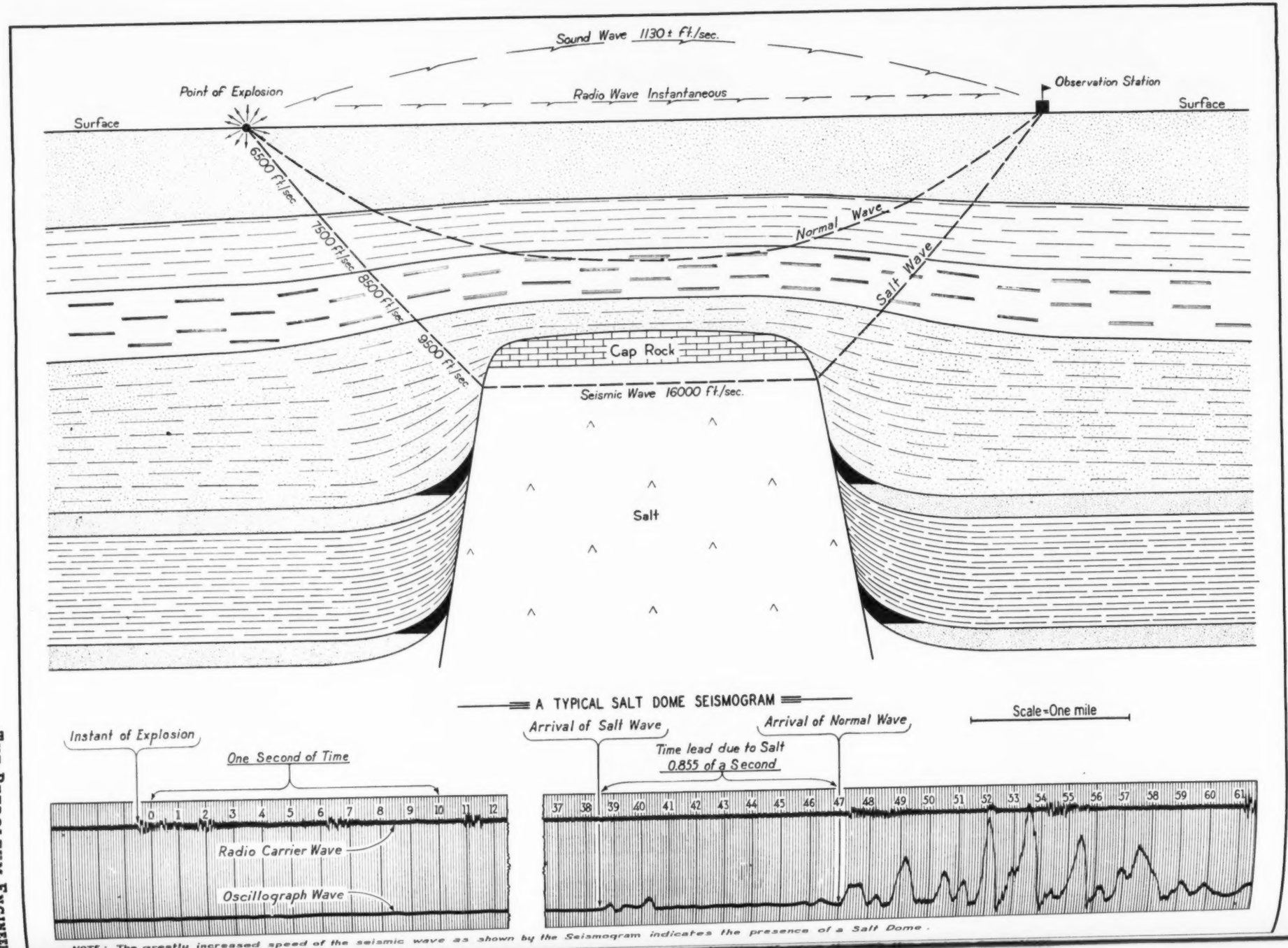

Sound Wave 1130± Ft./sec.
Point of Explosion
Radio Wave Instantaneous
Observation Station
Surface
Surface
6500 Ft./sec.
7500 Ft./sec.
8500 Ft./sec.
9500 Ft./sec.
Normal Wave
Salt Wave
Cap Rock
Seismic Wave 16000 Ft./sec.
Salt
A TYPICAL SALT DOME SEISMOGRAM
Scale=One mile
Instant of Explosion
One Second of Time
Arrival of Salt Wave
Arrival of Normal Wave
Time lead due to Salt
0.855 of a Second
0 1 2 3 4 5 6 7 8 9 10 11 12
37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
Radio Carrier Wave
Oscillograph Wave
NOTE: The greatly increased speed of the seismic wave as shown by the Seismogram indicates the presence of a Salt Dome.

Fig. 14. View showing general character of southern Louisiana marsh land and bayous and method of barging dynamite and supplies to location for refraction seismograph operations.

how much more the level surface is curved in one direction than another, and in which direction the curvature is least. The level surface is curved to correspond with the curvature of the earth. It was known that mountains and high hills warped this surface and it was found that buried salt domes and granite ridges likewise affected the earth's normal curvature.

It was at this point that Baron v.

Fig. 15. Carrying geophysical equipment to a field station located in swamp in the vicinity of White Castle, Louisiana. The cypress trees in the foreground show the high-water mark of the Mississippi flood of 1927. The marks of this overflow show about 15 ft. above the present water surface.

Eötvös invented the so-called torsion balance of the second order, which is now known everywhere as the Eötvös balance. (See Fig. 5.) He simply took the Coulomb balance and lowered one of the counterbalance weights about two ft. below the plane of the horizontal beam. This meant that now one weight was closer to the center of the earth than the other and gravity at each station would affect the weights differently. The new balance, therefore, responded not only to the curvature effects on gravity, but to the effects of horizontal variation in the intensity of gravity.

For example, in the gulf coast of Texas there are many salt domes with massive cap rock near the surface but sufficiently covered to be permanently concealed from actual view. The cap rock is much denser (heavier) than the surrounding beds. As the torsion balance is moved progressively across country its approach to the buried dome will express itself in the increase in the gravity pull exerted on the balance weights. The tendency of this influence will be compensated by the torsion in the wire suspending the balance, and there will be a measurable distortion. From the amount of this distortion and its direction it is possible to calculate and plot the gradient. The original Eötvös instruments permitted, by means of a telescopic eyepiece, the direct reading of this distortion.

About the year 1910, Professor Oscar Hecker, of the Geodetic Institute of Potsdam in Germany, provided himself with an Eötvös balance for experimentation. The first commercial application of the torsion balance began almost simultaneously in Germany and Austria. In Germany about 1916, an official of the Deutsche Bank, Herr von Stauss, proposed and Professor W. Schweydar carried out a torsion bal-

Fig. 16. A refraction seismograph set-up in the open grass marsh along the southern Louisiana coast.

NOTE: The greatly increased speed of the seismic wave as shown by the Seismogram indicates the presence of a Salt Dome.

Fig. 17. Preparation for the planting of a charge of dynamite of several hundred pounds for a refraction seismograph shot. The hole is hand-augered about 20 ft. and a small cavity blown at the bottom of this boring into which is then dropped the entire 500 lb. of dynamite.

ance survey of the known Wathlingen salt dome near Hannover. The well-known German oil field of Nienhagen already occupied the west flank of the dome. Professor Schweydar conclusively proved the gravity anomaly of the salt structure and published these results in the Zeitschrift Fur Praktische Geologie, November, 1918.

About the same time Hugo von Boeckh was carrying out a torsion balance investigation of the Egbell oil field in the Vienna Basin near Vienna. This field is on an anticlinal structure. The results of this survey were published in Zeitschrift Fur Petroleum, Vienna, May, 1917, under the title of "Indications of Brachy Anticlines and Domes by Means of Torsion Balance." It was the specific results on Wathlingen and Egbell that brought the method to the attention of oil exploration companies. The Royal Dutch Shell and the Anglo-Persian companies took up the torsion balance at this point and began to make world-wide use of it.

Professor Schweydar, in co-operation with the instrument manufacturing company of Carl Bamberg of Germany (now Askania), made improvements to the Eötvös balance by designing a better system of automatic photographic recording of the distortion of the beam, and by building a smaller balance known as the "Z-bar" type (see Figs. 6 and 7). The torsion balance in field operation is shown by Figs. 8 and 9. In addition to improved mechanical construction Professor Schweydar also made valuable contributions to the formulae for the calculation of terrain, or local ground, effects and their correction.

About 1920, E. DeGolyer, head of the Amerada-Rycade Oil Companies, became interested in the instrument. In 1922 Donald C. Barton, well-known American geologist and geophysicist, proceeded to Budapest at DeGolyer's instance, and acquired two of the balances. In the same year the Royal Dutch Shell and the Amerada-Rycade both brought torsion balances into the Texas gulf coast.

The Rycade's discovery, under Barton's supervision, of the Nash salt dome in Fort Bend County, Texas, in 1924, was the first salt dome torsion balance find in the United States. This was followed in the spring of 1925 by the Shell's torsion balance discovery of the Allen and Clemens domes, both in Brazoria County.

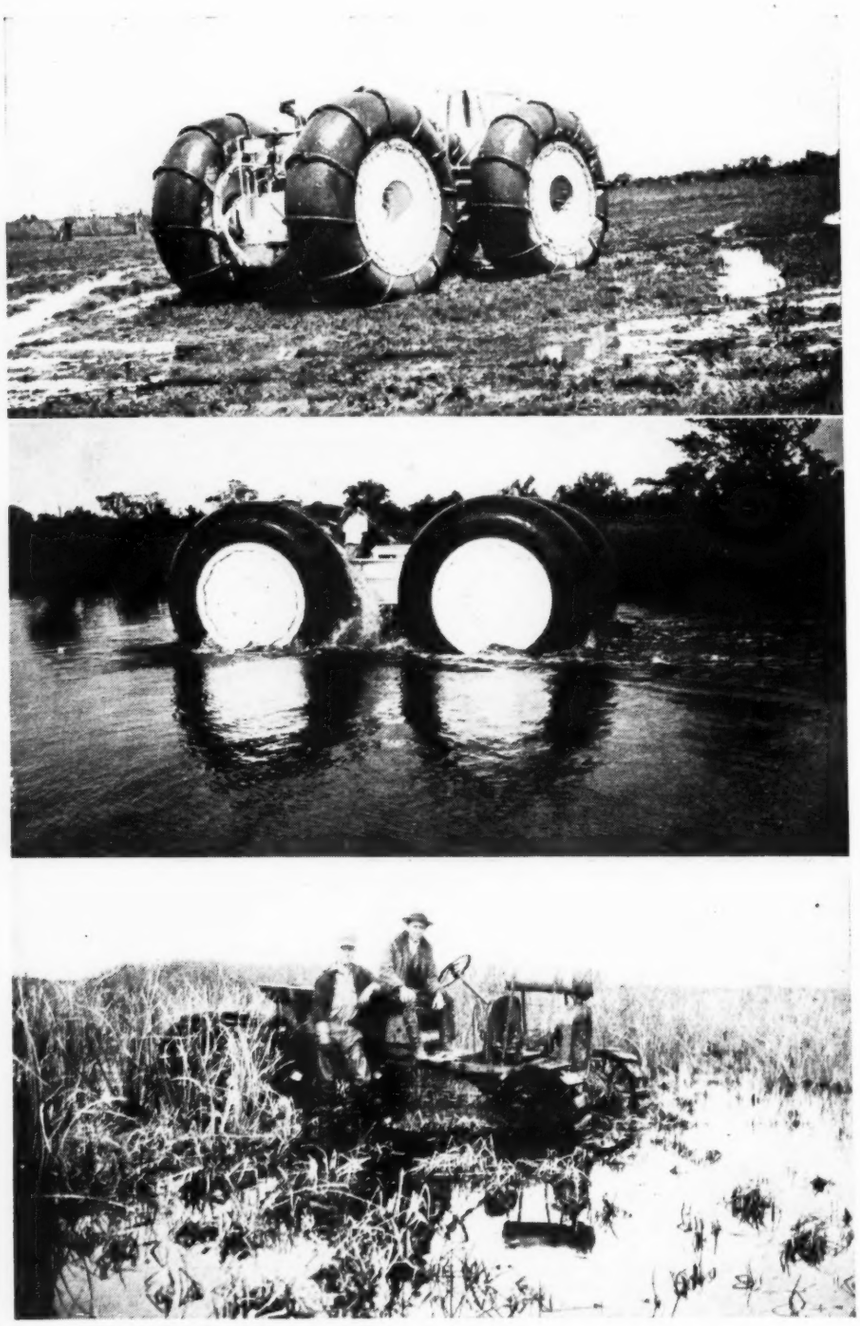
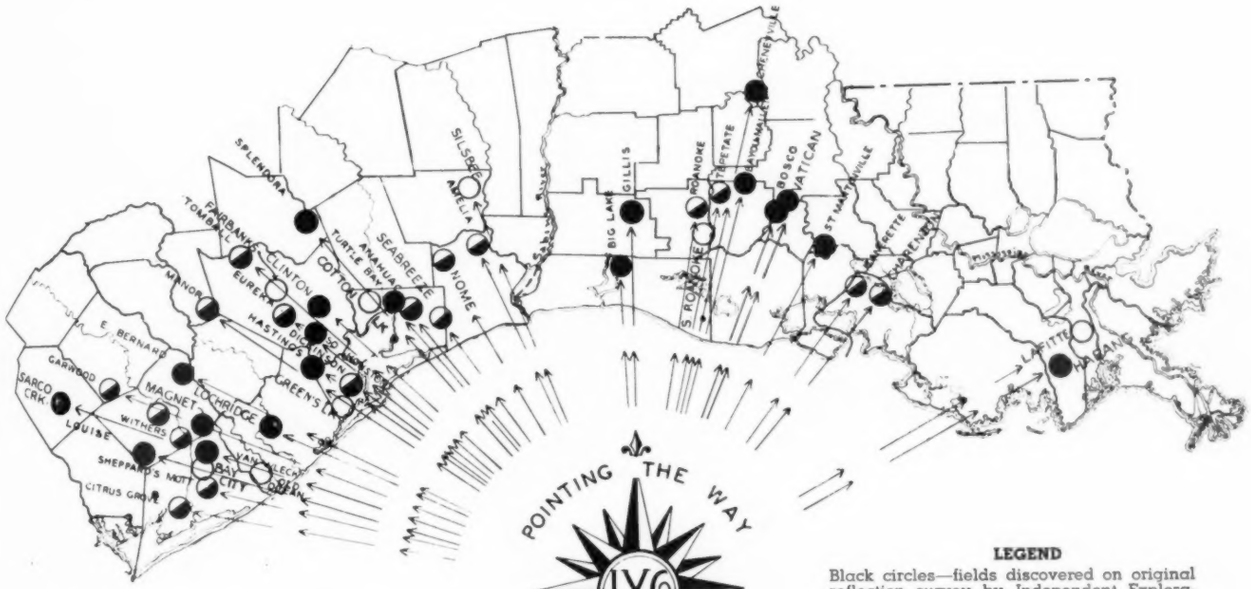


Fig. 18. Marsh buggies used for the transportation of material across the grassy lowlands. The marsh buggy with the broad wooden cleets was used about 1928. The mammoth balloon tired buggy, capable of navigating either on land or water, is the latest design and put in use by the Gulf Oil Corporation in 1937.

RESULTS ACHIEVED

Are the ultimate test of any method of procedure. Since 1932 (date of organization of our Company) there have been proved for production in the Texas-Louisiana Gulf Coast Province **forty-four (44) geophysically-discovered fields.** Of this number, 19 fields (43%) were found on original Reflection Seismograph work done by our Company; 17 fields (39%) were found in areas checked by our Company and recommended by us for drilling, prior to any development; that is, **82% of the total geophysical "hits" were scored by Independent Exploration Company.**



LEGEND

Black circles—fields discovered on original reflection survey by Independent Exploration Company	19
Half-black circles — proved fields checked and recommended by Independent Exploration Company (prior to development) for drilling	17
	36
Total number of fields	44

In the Western States, we operate as Colorado Geophysical Corporation, 610 Midland Savings Bldg., Denver, Colorado. In the Eastern States, Canada, Mexico and Foreign Countries, we operate as Pathfinder Prospecting Company, 120 Broadway, New York City.

INDEPENDENT EXPLORATION COMPANY

ESPERSON BLDG. HOUSTON, TEXAS

Fig. 19. An observation, or recording boat used in refraction seismograph shooting in the bayous of southern Louisiana. The seismograph detector is lowered to the bottom of the water body and the seismic impulse is recorded by means of electrical magnification. Note the radio antenna for the use of two-way radio communication.

The torsion balance has affected tremendously the search for the minerals of the earth, most notably oil. Oil fields discovered by this method have added hundreds of millions of barrels of oil to the known reserves of the world. As an instrument of exploration it will be used for many years to come.

In contradistinction to the measurement of the rate of change of gravity in a horizontal plane, there are several instruments designed to make direct readings of the vertical intensity of gravity. Among these principally are the gravity pendulum and the gravitimeter or gravimeter.

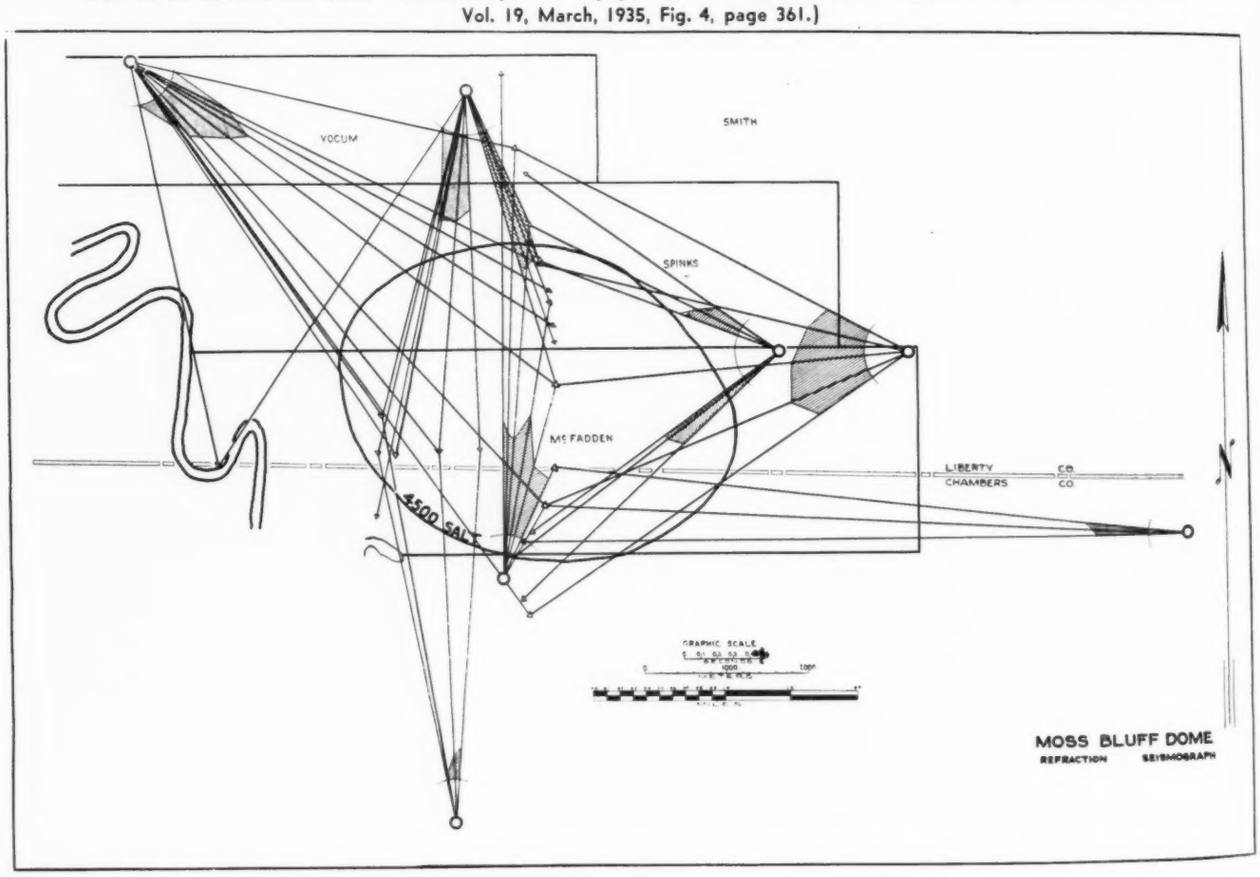
The pendulum method is based on the fact that gravity itself affects the oscillation of a free-swinging pendulum. In field practice one pendulum is set up at a base station and a second pendulum is moved from place to place and the oscillations of the two checked. Any change in the period of the field pendulum from the one at the base can be noted and the gravity difference calculated.

There are two principal types of gravitimeters, the "spring" type and the "barometer" type, both of which

Fig. 20. A typical road-side mechanical seismograph set-up with the operating tent removed to display the instruments. The seismograph and oscillograph show to the right side of the radio transmitter and the recording camera shows at the extreme left of the picture.

are designed to measure the vertical component of gravity. The spring type is simple in principle, consisting of a metal weight suspended by a horizontal

Fig. 21. Refraction seismograph map of the Moss Bluff Dome, Liberty and Chambers counties, Texas. The shaded pattern represents the amount of acceleration of the velocity of seismic waves that pass into or through the salt dome. By means of these accelerations the presence of an unknown salt dome is revealed. (See "Geophysics of Salt Dome Structures" Bulletin of Am. Assoc. Pet. Geol., Vol. 19, March, 1935, Fig. 4, page 361.)



G.S.I.

EXPERIENCE *plus*

G.S.I. for seven years has been making successful reflection seismograph surveys in Canada, United States, Mexico, Venezuela, and Colombia. Those years of experience, under the leadership of men dominant in bringing the art of geophysics to its present stage, mean a maximum return on every dollar invested in seismic exploration.

• Our new and modern Laboratory and service building is pictured above. It is symbolic of our determination to keep ahead of the field with instruments and equipment as perfect as human skill can contrive and master craftsmen can build.

GEOPHYSICAL SERVICE · INC.

DALLAS

sheet metal spring. Variations in gravity will affect the weight accordingly and by optically amplifying these displacements a direct measure of gravity can be ascertained. In the barometer type, a mercury column is handled identically as in the common mercury barometer, except that the tube is sealed to prevent the effect of atmospheric pressure. The column of mercury no longer subject to atmospheric changes, varies in height from place to place only by the difference in gravity at different locations.

The average gravimeter is accurate to about the three millionth part of gravity and the best pendulum to the two millionth part of gravity.

THE SEISMOGRAPH

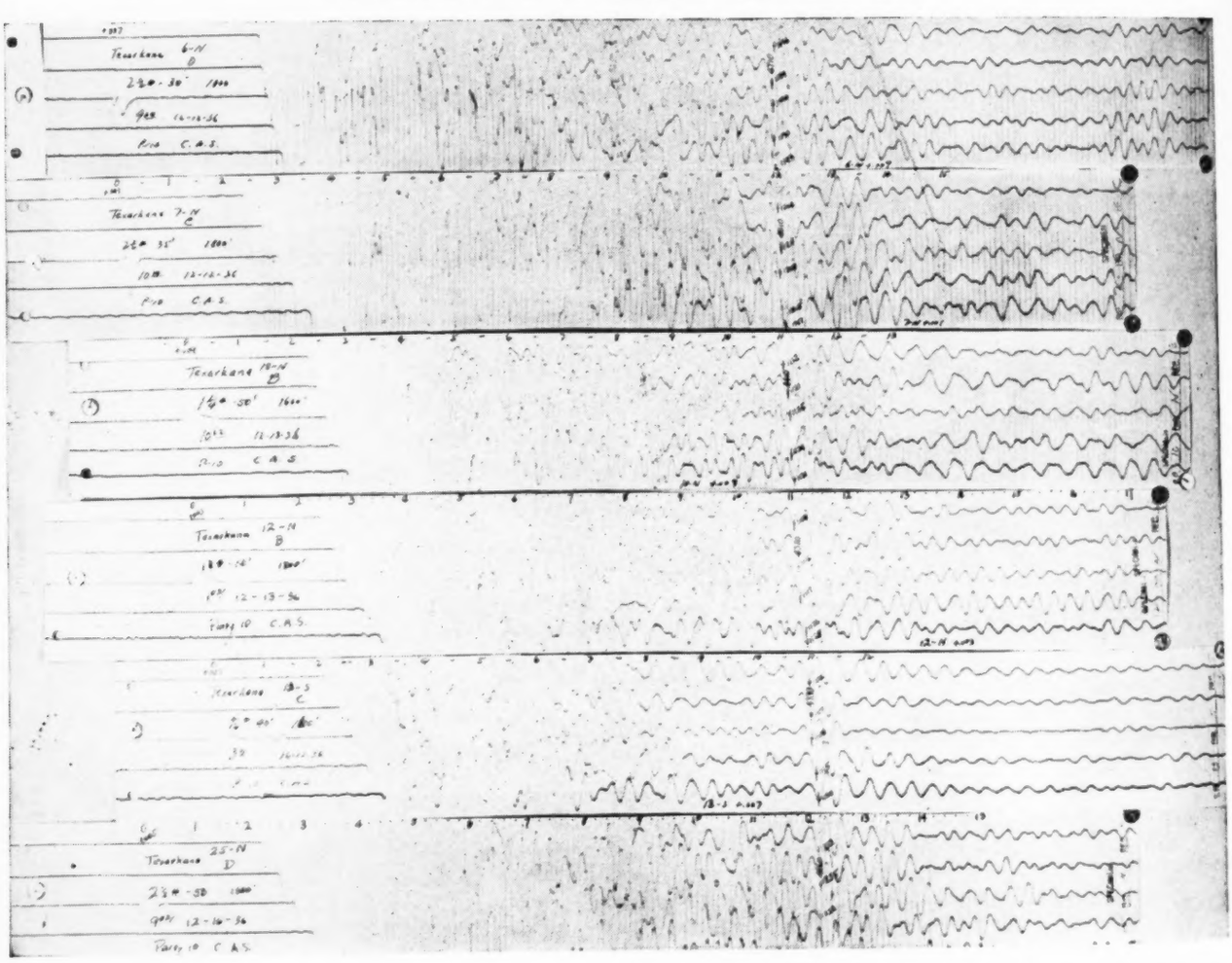
No single instrument or method has exerted a greater influence on geophysical exploration than the seismograph. The mineral wealth it has uncovered can be estimated only in thousands of millions of dollars. By its extraordinary success in the past and its promise for the future it has lifted itself to a unique position in the history of mineral exploration.

A seismograph, as almost everyone knows, is an instrument for recording the shock of earthquakes. In applied geophysics the seismograph is an instrument for recording the shock of small artificial "earthquakes," Figs. 10, 11, and 12. These miniature quakes are caused by buried dynamite explosions. The effect of the shocks on the seismograph are photographically recorded on strips of paper called "seismograms," Fig. 13. From the data on these seismograms the speed with which the seismic or elastic wave travels through the various rock strata can be determined and hence much can be learned of the character and structure of these subsurface beds, as well as of the depth of the structure itself.

The development of the commercial seismograph owes much to the studies in earth seismology made by the late Emil Wiechert, professor of Geophysics at Goettingen, Germany, and a group of his student associates. Among these associates are those whose names hold the highest rank in seismology, namely, K. Zoeppritz, Gutenberg, Geiger, and others. The applied seismic method has as its scientific basis the principles of earth seismology. From seismograph records taken in earthquake observatories much information has been gained concerning the structure and character of the interior of the earth.

In a paper published in 1907 by the Royal Society of Science at Goettingen (The Proceedings), Wiechert and Zoeppritz found that the earth consisted of an outer shell about 900 miles thick and an inner core. The velocity of earthquake waves was found to increase downward from 7 to 13 km.

Fig. 22. Correlation of six reflection seismograph records taken in southwestern Arkansas a few miles south of Texarkana. The outstanding reflection shown by these records is from the anhydrite series of the Trinity formation. The approximate depths of these reflections are indicated on the various seismograms (on the first, for example, 4710 feet.) A distance of from 1600 to 1800 ft. from the shot point to the middle recorder was used and the shot holes varied from 30 to 50 feet in depth. This interesting set of seismograms and correlations were made by the Independent Exploration Company.



Symphony OR JAZZ?

LOOKING AT THE RECORD WON'T TELL YOU...

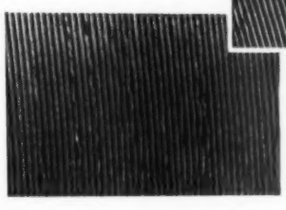
The human eye is not always the best means for interpreting sound vibrations. For example, a phonograph record may be examined through the best of modern microscopes without revealing the nature of the music it carries. When reproduced through a properly designed phonograph, however, the content of such a record is fully revealed.

Reflection records of earth vibrations present a similar situation. When reproduced on a machine, details are disclosed which are not evident to the eye. In the Rieber Sonograph System of geophysical exploration, reflected waves are recorded on sound film, producing a record which can be read and interpreted by the Rieber Sonograph Analyzer. From the multitude of waves recorded on the film, the Sonograph Analyzer singles out any one or any group, determines accurately the direction and time of arrival of each, and is not baffled by numerous and overlapping wave trains.

The original evidence gathered in the field and preserved on the sound film can be diagnosed repeatedly by the Sonograph Analyzer in the central laboratory, just as a record is played again and again on a phonograph. The exhaustive study of accurate data thus made possible enables the geologist and geophysicist to map satisfactorily structures formerly thought unshootable.

The Rieber Sonograph System is the *only* geophysical apparatus which interprets reflection records by a reproducing machine. It is the method of choice for all exacting problems in exploration.

A limited number of field parties is available for work in California, Mid-Continent and Gulf Coast areas.



A record of a symphony at top. Below, a popular dance tune. The vibrations on geophysical records, too, may be undecipherable to the eye, yet their true meaning is revealed when interpreted by a machine.

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per sec. (about 23,000 ft. to 42,000 ft. per sec.) in the outer shell but remained constant in the core, A little later Wiechert and his group found the earth to be built up of several concentric shells ranging in thickness from the surface of 1200 km. (750 miles), 1700 km. (1,050 miles), and 2400 km. (1,500 miles), and the core at 2900 km. (1,800 miles).

Still later, in 1909, A. Mohorovicic, of Zagreb (Agram) formerly in Austria and now Jugoslavia, found from a study of natural earthquake waves that there should be, at about a depth of 50 km. (27 miles), an interface (or surface of one of the earth shells) at which the velocity of seismic waves suddenly change from 5.6 km. per sec. to 7.8 km. per second. He pointed out that in knowing the depth of this interface it might be possible to observe the waves that would be reflected back to the surface from this interface. He calculated the time-distance curve of these reflected waves, but apparently never did actually observe them.

The time-distance curve is so important to applied seismology it should be described at this point. It is a simple graph with time as a vertical coördinate and distance as the horizontal coördinate. Thus, if an earthquake wave is observed to move certain distances in certain times, these points plotted on the graph give the necessary data from which the velocity of the seismic wave can be calculated at any given point. Variations in the velocity of the wave easily can be seen by the bends (or breaks) in the curve.

Wiechert, Zoeppritz, Mohorovicic, and others now recognized the different types of waves that passed through solid rocks. There were defined the longitudinal wave, in which all particles vibrate in the direction of the propogation, the transverse wave in which the particles vibrate at right angles (transverse) to the path of propogation, and the surface or rolling ground wave known also as the Love or Rayleigh wave. It is the longitudinal wave that is chiefly of interest in applied seismology.

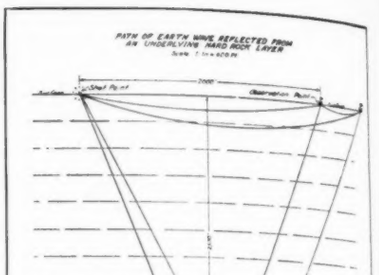

Fig. 24. (After Geophysical Prospecting—1931 by Atlas Powder Company.)

For many years seismologists had recorded the actual speed of artificial earthquake waves through various rock beds.[1] The earliest of these was Robert Mallet, an English physicist, in 1850, who obtained velocities in wet sand, sandstone, and granite. Many other seismologists in the next 60 years made similar measurements but always on the surface, and in no instances on beds of rocks that were buried or overlain by other material.

In 1917, R. A. Fessenden, American scientist of Boston, was the first to develop a method of determining the presence of ore bodies by sending and recording periodic sound waves between two points in the subsurface. He placed both his sound-sending device and recorder in boreholes filled

[1]Two excellent summaries of the seismic method were published by the Seismos Company, Hannover, Germany. The first, in 1922, is entitled, "The Exploration of Rock Strata and Mineral Deposits by the Seismic Method." The second in 1930, is entitled, "On the history of the Seismic Method for the Investigation of Underground Formations and Mineral Deposits," by Dr. L. Mintrop.

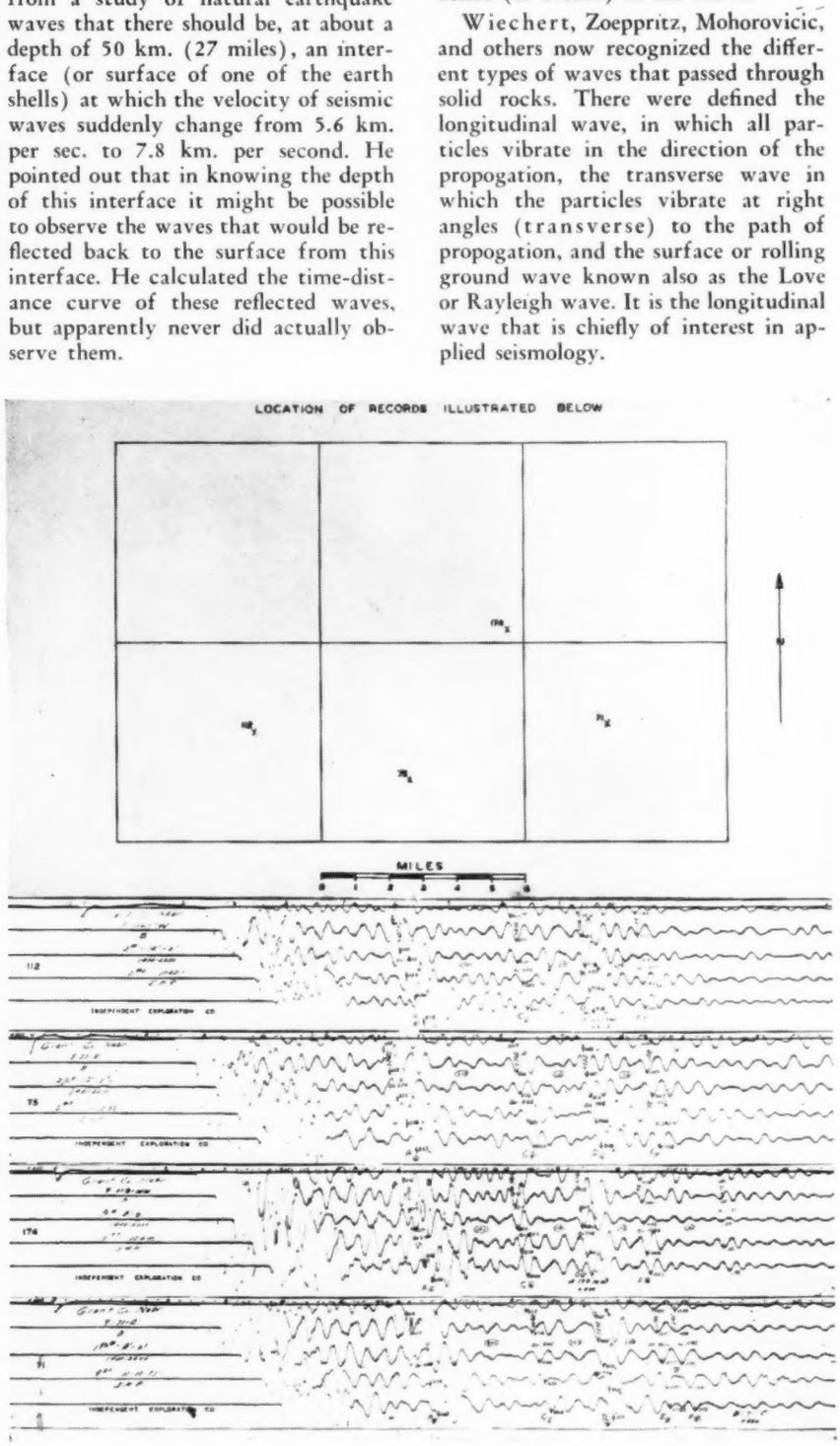

Fig. 23. Correlation of four reflection seismograph records taken in the central part of Grant County, Nebraska. Several outstanding reflections can easily be seen. The "A" reflection is from the top of the Dakota sandstone, the "C" reflection is from a limestone in the Morrison formation and the "D" reflection is from the anhydrite. The deeper reflections are not yet identified. The records are from four different stations from four to six miles apart as indicated by the sketch map. These seismograms and correlations were made by the Colorado Geophysical Corporation, a subsidiary of the Independent Exploration Company.

with water and did not make use of the seismic method of exploration that is now in use.

The earliest attempt to use artificially-excited seismic waves for use in examining subsurface rocks from the surface was undertaken by Dr. L. Mintrop, a student of Professor Wiechert. His initial efforts were made early in 1908 and his first published reference to these experiments was in the mining magazine "Gluckauf," Essen, Germany, in 1909. A fuller explanation was given before the International Congress of Mining, Metallurgy, and Applied Geology, Dusseldorf, 1910, and published that year in its "Proceedings."

In 1920, he presented a paper on the subject before the German Geological Society meeting at Hannover.[2] He showed that the same physical rules that had been so successful in determining the seismological character of the interior of the earth could be used for the determination of the depth and character and elastic properties of different geologic strata covered or concealed at the surface by a thin overburden. By grasping the idea that all rock strata, irrespective of depth, would, if properly excited, carry an elastic wave that could be measured at the surface, and that these velocities could be analyzed by the ordinary time distance graph, Mintrop placed the seismic method squarely on a commercial basis.

Mintrop's first salt dome experience was carried out in 1920 on the Wietze dome near Hannover, Germany. This was followed by the investigation and discovery of the Meissendorf salt dome, near Wietze, which unquestionably ranks as the first important commercial discovery to the credit of the seismic method.

The first seismographs were introduced by Mintrop in America on the Mexican coastal plain, in the Golden Lane oil field in March, 1923, and into the United States in July, 1923, in Oklahoma. The instruments were brought to the Texas gulf coast in the spring of 1924. In June, 1924, the Orchard Dome in Fort Bend County was uncovered by a Mintrop party for the Gulf Production Company. This was the first United States seismograph dome discovery and was almost immediately followed by several others. The difficulties of transportation of seismic equipment in the Gulf Coast and the preparation of shotholes and seismic stations are shown by Figs. 14, 15, 16, 17, and 18.

The organization of the Geophysical Research Corporation by the Amerada-Rycade companies under E. DeGolyer's leadership spurred American participation in the rapidly growing application of seismic geophysics to oil exploration. A number of American scientists were contributing to the developing of the seismograph, among them Dr. J. C. Karcher, Burton McCollum, O. C. Petty, Eugene McDermott, Dr.

[2]Published in the Proceedings of the German Geological Society for 1920.

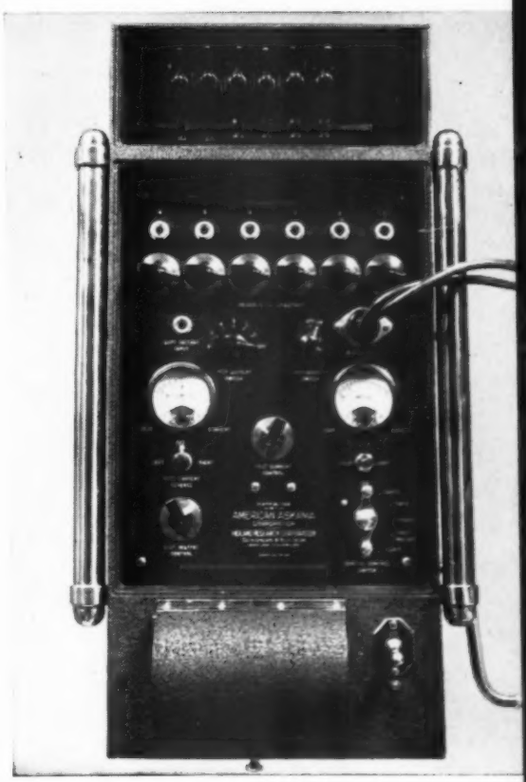

Fig. 25. Close up view of a reflection seismic recorder. This particular instrument is equipped with six detectors and is constructed to permit simultaneous visual observation and recording. (Courtesy of American Askania Corporation.)

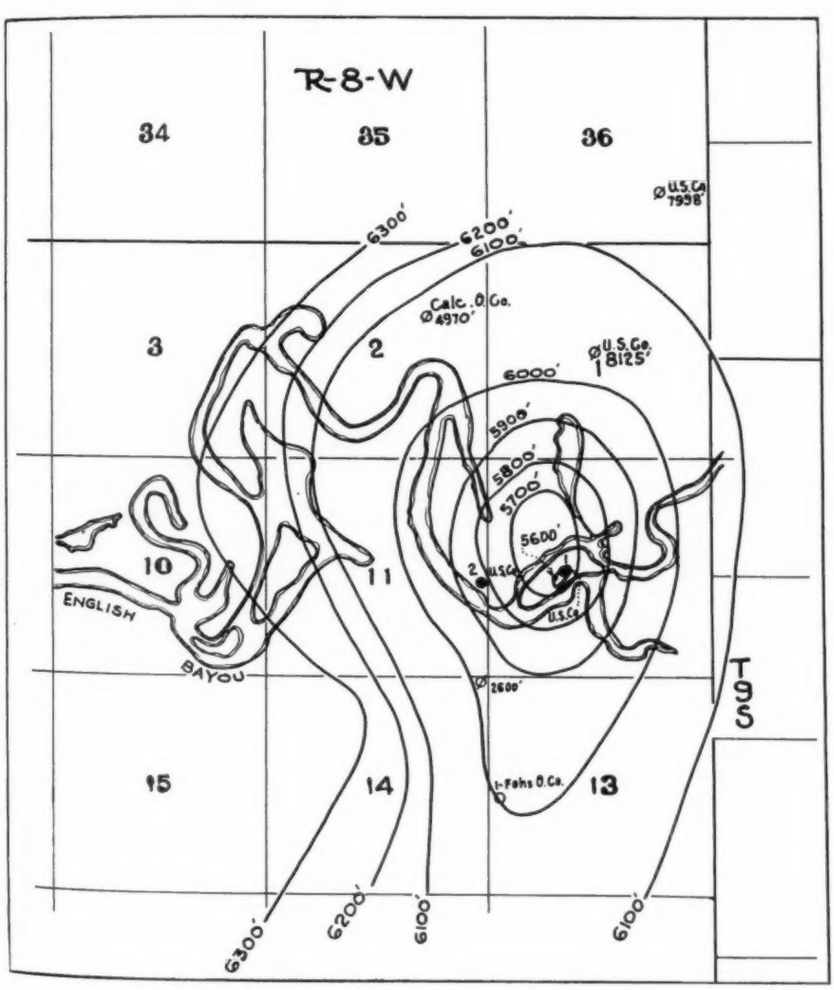

Fig. 26. Reflection seismograph map of English Bayou-Gillis oil field, by the Independent Exploration Company made prior to the discovery of oil. (See "Geophysics of Salt Dome Structures" Bulletin of Am. Association Pet. Geol. Vol. 19, March, 1935. Fig. 18, page 337.)

Eugene Rosaire, Frank Rieber, and Dr. C. A. Heiland.

The general method of procedure for the location of salt domes is indicated by the diagrammatic drawing shown in Fig. 13. This method of long distance shooting and recording (from four to seven miles) employs the use of the refracted seismograph wave. By finding abnormal velocities the presence of a salt dome would be indicated. Many improvements were developed both by Mintrop and the American geophysicists, such as the designing of electrical detectors for mechanical seismographs and the institution of radio for the transmitting of the instant of explosion (see Figs. 19 and 20). A completed refraction seismograph map is shown by Fig. 21.

The introduction of the electric seismograph made possible the simultaneous recording of the seismic impulse at several stations on the same seismogram. Attention is directed to an article in this issue by E. E. McDermott, on the use of multiple seismometers. It now became possible to identify the different types of waves, especially reflected waves. Examples of this are given by Figs. 22 and 23. The shot points and receivers are spaced at fixed distances depending on the depth to which it is desired to explore for reflections. (See Figs. 24 and 25.) This is the so-called method of reflection seismograph exploration.

A new device in seismic geophysical exploration is offered by the invention and use of the Rieber Sonograph and Photoelectric Analyzer and operating methods. (See article by Rieber in this issue). In field practice the many reflections sent back from complex structures are photographically recorded on ten separate sound tracks on a film. When these are sorted out and transcribed by the photoelectric analyzer it is possible to identify and use many reflections that otherwise would be impossible to recognize.

Seismic exploration in the United States is now being carried out almost entirely by reflection work. It has been found that invariably reflected seismic waves will be returned to the surface from every plane or layer that represents a sharp difference in the density of the rocks above and below the particular plane or subsurface layer. Remarkably accurate work is now being accomplished by detailed reflection surveys in mapping the structure of subsurface rocks that heretofore has evaded the best efforts of the refraction seismograph to locate. (See Figs. 26 and 27.)

The Magnetometer

The ordinary magnetic compass is well known to all. The fact that it points to the north (magnetic) pole anywhere in the northern hemisphere makes it immediately apparent that the earth itself acts as a huge magnet and hence everywhere over the earth there exists a definite magnetic force that will cause a freely swinging magnetic needle to align itself in accordance with the "lines" of this force.

In applied geophysics the use of magnetics recognizes the fact that different kinds of rocks both on the surface and under the surface will exhibit different magnetic properties, and thus create inequalities or anomalies in the normal earth's magnetic field. The measurement of these anomalies and their interpretation is the province of the magnetometer geophysicist.

All magnetic values appearing on maps showing oil or mineral prospects are given in units called gammas. Lines connecting all points of the same gamma value are called isogams and appear much as structural or topographic contours. Thus a magnetic high will appear as so many gammas above normal or a magnetic low will appear as so many gammas below normal.

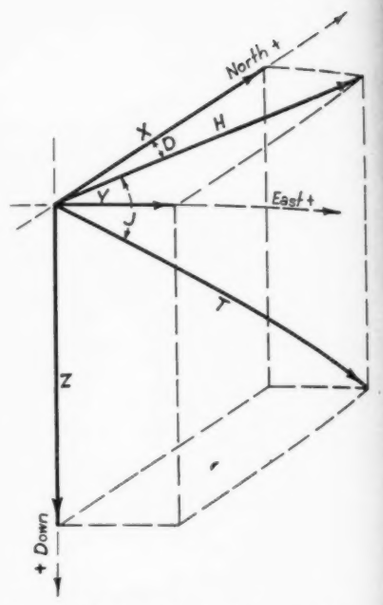

Fig. 28. Diagram illustrating general intensity of earth's magnetism by "T" and showing the various components and angle of declination and angle of dip.

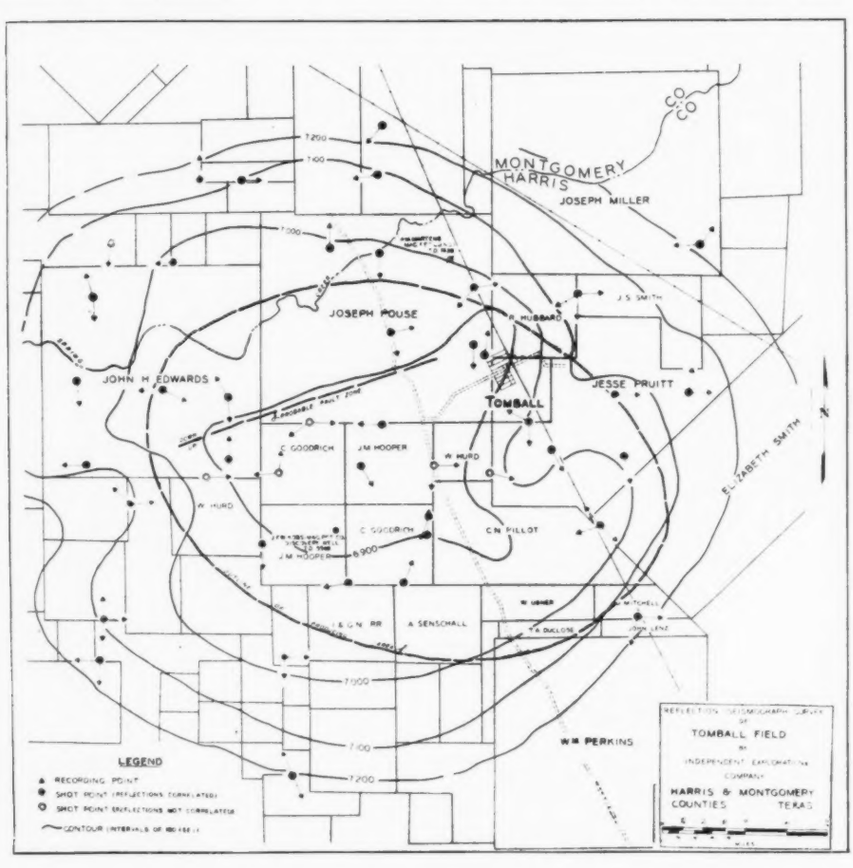

Fig. 27. Reflection seismograph map of the Tomball oil field by the Independent Exploration Company, made prior to the drilling of the discovery well in this field. The outline of the producing area as of November, 1935, is indicated on the map. (See "Geophysics Tomball Oil Field" Bulletin Society of Petroleum Geophysicists. Vol. I, 1936, Fig. 5, page 157.)

Dependable seismic reflection surveys accurately interpreted.

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Fig. 29. The magnetic vertical field balance. (See American Askania Corporation pamphlet, Geo. 118 E a.)

The system of measuring magnetic force and breaking it into usable units was designed by Karl F. Gauss, (1777-1855), an especially gifted German mathematician and astronomer, director of the Astronomical Institute at Goettingen. Two magnetic poles of equal strength, but acting in opposite directions, have unit strength if they attract each other with the force of one dyne at one cm. distance. It will be recalled from the discussion of the torsion balance that average gravity is expressed as 981 c.g.s. units. A dyne is described as 1/981th of the force with which the earth attracts one gram, in other words 1/981 of gravity. This unit of strength is called a "gauss," honoring the founder. Since today an ordinary magnetic balance is accurate to better than one twenty thousandths of a gauss this unit is arbitrarily di-

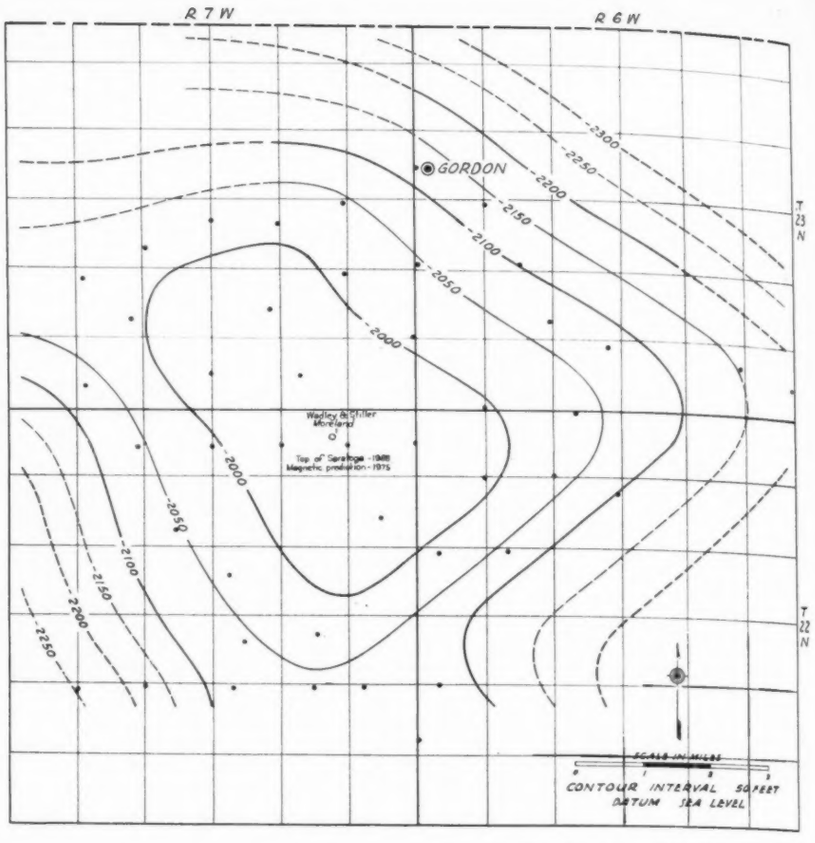

Fig. 31. Gordon Area, Claiborne Parish, Louisiana, showing calculated contours top of Saratoga chalk and locations of magnetic stations. (Courtesy Wm. M. Barret, Inc.)

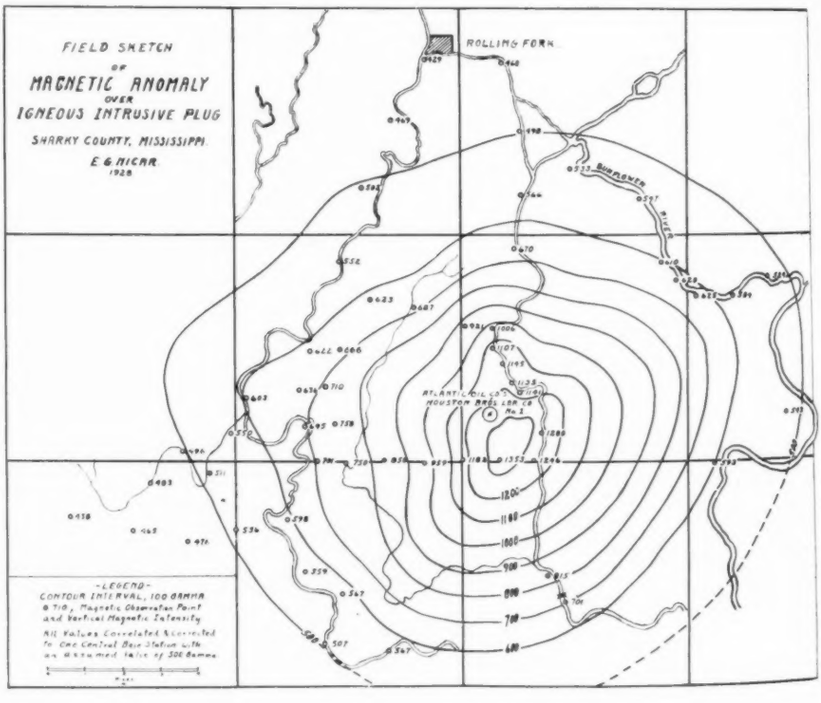

Fig. 30. A magnetic map of an igneous intrusive plug located in central Sharkey County, Mississippi. This anomaly was discovered by E. G. Nicar, geophysicist, Houston, Texas, in the spring of 1928. A well was drilled at the position indicated on the map, by the Atlantic Oil Company, and igneous material was encountered at an approximate depth of 3100 feet. The total magnetic relief is about 800 gamma. All magnetic values are correlated on an assumed value of 500 gammas for a base station north of Rolling Fork. Much of the area covered by this magnetic picture lies in low flat lands typical of the Mississippi delta region. The magnetic maximum lies in the center of the Little Sun flower river swamp, which extends several miles in all directions.

vided into 100,000 smaller units called gammas.

The general character of magnetic force at any given point on the earth is indicated by the following simple diagram, Fig. 28, showing the relation of the various components.[3]

The total intensity of the earth's magnetism exerted on a unit pole is expressed by the magnitude "T". The vertical component is "Z," the horizontal component "H." The angle "D" is the well-known compass angle of declination, and the angle "J" the dip. "X" and "Y" are the ordinary north and east components of the horizontal intensity "H."

The vertical intensity reaches its maximum value at north magnetic pole and zero at the magnetic equator (close to but not exactly the geographical equator). The vertical intensity ranges in value from —.674 gauss in the southern hemisphere to +.634 gauss in the northern hemisphere. The horizontal intensity on the other hand ranges from zero at the magnetic poles to 0.39 gauss, its highest value, at the magnetic equator.

Since in applied magnetic geophysics interest is chiefly concerned in the magnetic properties of rocks below the surface at any given point, the vertical intensity becomes the most important component of magnetic force to the geologist. The special type magnetometer for measuring vertical intensity is called the magnetic field balance, or vertical variometer.

The vertical balance is a magnetic needle, or magnet, that is permitted to swing freely only in a vertical plane. (See Fig. 29.) It is usually affixed to a quartz wedge balanced on a steel knife edge. By means of a scale attached to the balance in juxtaposition to a fixed scale, and with the aid of a telescopic eye-piece, the operator of the balance can read directly variations in magnetic intensity from place to place.[4]

In addition to magnetic anomalies due to subsurface conditions, the operator must consider many other magnetic disturbances. There is a general shifting of magnetic intensity over a period of years and the United States Coast and Geodetic Survey publish each five years magnetic maps showing the regional change and amount of this shift. There also are changes daily that the operator must observe and correct for himself. Then there are magnetic "storms" or violent disturbances that are erratic and unpredictable. The cause of these "storms" is still an open problem, many scientists attributing them to sun spot disturbances to the earth's electro-magnetic field. Actual weather conditions show no relation to magnetic "storms," Dr. W. Jenny, Houston geophysicist, reporting excellent magnetic "weather" in the midst of a typical West Texas Panhandle sandstorm. Conversely, the most errant magnetic "weather" will frequently occur on the clearest day.

The latest design of A. Schmidt's magnetic balance, Fig. 29, following his invention in 1914 of the first practical vertical balance, can be operated on an accuracy of five gammas or slightly less in some territory. Ore bodies and igneous plugs will give mag-

[3]See Ambronn-Cobb, Elements of Geophysics, 1928, Fig. 23, page 61.

[4]For those desiring more detailed information on the magnetic theory and field practice, a new book entitled "Manual of Geophysical Prospecting with the Magnetometer," by J. Wallace Joyce, is now being published by the American Askania Corporation under co-operative agreement with the United States Bureau of Mines. It will be distributed through the Houston, Texas, office of American Askania Corporation.

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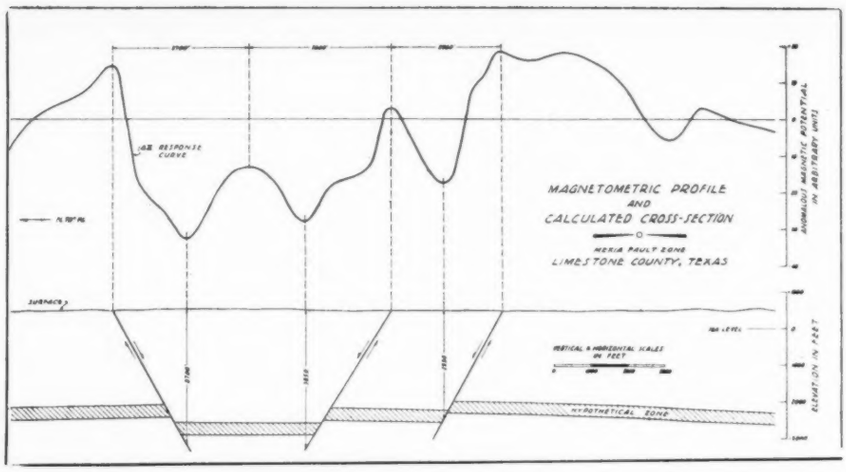

Fig. 32. Profile made from survey with magnetometer. (Courtesy Wm. M. Barret, Inc.)

netic anomalies of 100 to 1000 gammas (see Fig. 30). Salt domes containing less magnetic minerals than the surrounding sediments show slight negative "pictures" ranging from a few to 40 or 50 gammas. Generally speaking, salt domes yield comparatively indefinite reactions to magnetic treatment and this method of exploration has not prospered in dome territories.

In the Mid-Continent area, Wm. M. Barrett, Shreveport geophysicist, has developed the magnetic method of exploration into two general types known as "quantitative magnetometric" and "qualitative magnetometric" surveys. The "quantitative survey" permits a determination of the quantitative or actual structure of a number of magnetically competent subsurface zones or beds. An example of this is indicated by the magnetic map of the Gordon area, shown in Fig. 31.

The "qualitative survey" uses magnetic measurements to correlate different sections of the stratigraphic column disclosing the qualitative or relative structure of an area. An example of this is the Limestone County fault work shown in Fig. 32. Both types of surveys require vertical and horizontal magnetic measurements.

The torsion balance, gravitimeter, seismograph, and magnetometer are the principal instruments of geophysics now in use. The use of electric current measurements is discussed in another article in this issue by J. J. Jakosky and C. H. Wilson. The measurement of radioactive emanations and the hydro-carbon content of sub-soil gases are methods now receiving considerable experimental effort.

Today geophysics is receiving a tremendous play in the Gulf Coast, Mid-Continent, and California, of the United States. It is being used in Mexico, Brazil, Venezuela, and the Argentine. In Europe it is being intensively exploited in Germany by both the government and private companies. Russia, the Dutch East Indies, and to a smaller extent China and Japan are being investigated especially by torsion balance and seismograph. Many other countries are being introduced to geophysical methods. Verily, indeed, geophysics is spreading to the farthest corners of the earth.

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Use of Multiple Seismometers

By EUGENE McDERMOTT*

FIVE years' application in the field has established the advantages of an arrangement of multiple seismometers (or detectors) as a means of discriminating between reflections and undesirable disturbances, such as ground wave, wind, and traffic disturbances. In this article the writer will attempt to explain on a theoretical basis the manner in which this is accomplished. The seismometers (say eight) are placed in profile at some distance from the shot point and connected in series. The output of the group of seismometers so connected is applied to an amplifier, the output being photographed. This output represents the accumulated effect of all eight seismometers.

*Geophysical Service, Dallas, Texas.

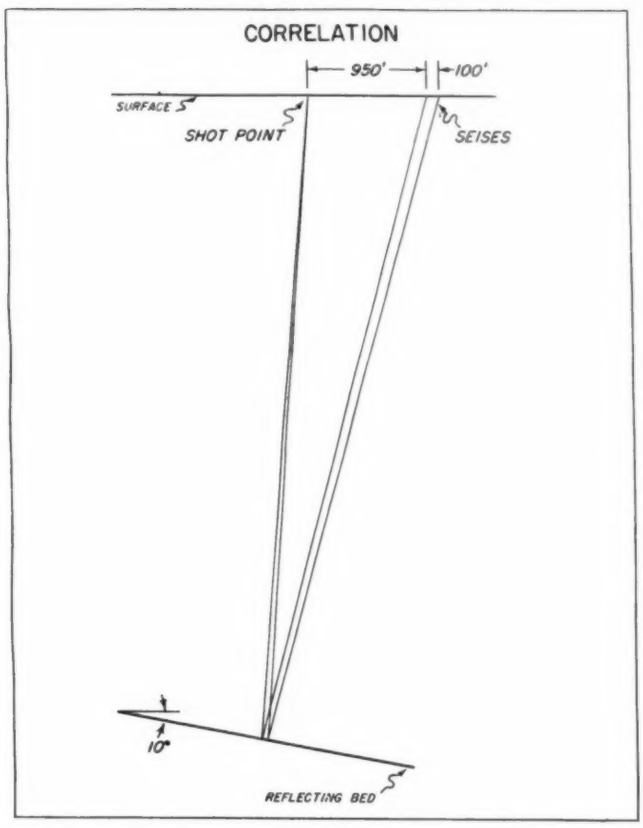
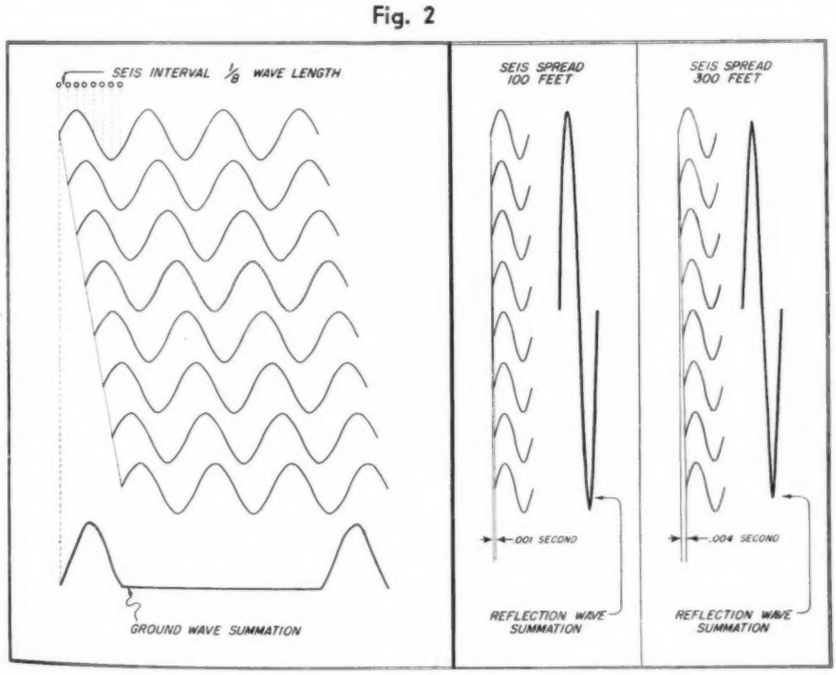


Fig. 1

In Fig. 1 is shown a group of eight seismometers covering a surface spread of 100 ft. the first being placed at a distance of 1000 ft. from the shot point. The paths are shown of the reflected waves arriving at the first and last seismometers of the group from a reflecting bed 6000 ft. deep and dipping at an angle of ten degrees. It is immediately obvious that the two paths are very little different in length; consequently, the reflected waves will arrive at all eight seismometers at approximately the same time — in this instance the maximum difference will be three thousandths of a second. As this time is small compared to the period of the reflected wave, they will add to give a resultant almost eight times as large as a single reflected wave. As other disturbances arriving at the seismometers will not satisfy this condition they will tend to cancel each other.

In Fig. 2 is shown the relative response of the seismometers to reflected waves and ground waves. The set-up is as shown in Fig. 1, except that the reflection bed is not dipping. The effect of dips will be considered separately. The ground wave is assumed to have a wave length of 100 ft. and a frequency of 20 cycles per second. The reflected waves are of 40 cycles and are assumed to be traveling at an average velocity of 8000 ft. per second. The seismometers are spaced one-eighth the wave length of the ground wave. The first seismometer is 1000 ft. distant from the shot point. The duration of the ground wave is assumed to be three and one-half cycles. The left side of Fig. 2 shows the summation of the

Fig. 2



ground waves, whereas, the right side shows the summation of the reflected waves. It should be noted that the maximum time difference between the reflected waves is only one thousandth of a second, which explains why the summation of the eight reflected waves is almost eight times the amplitude of the individual waves. It is thus seen that the discrimination between the reflected and ground waves is quite large. If the ground wave were assumed to continue for a longer time, the second maximum in the summation would move to the right. Although the amplitude of the ground wave is assumed to be constant with distance, in practice it will decrease; however, at a distance of 1000 ft. from the shot point this decrease over the distance of a wave length, namely, 100 ft., should not be great.

In practice it is not always possible to determine accurately the wave length of the ground wave. As this wave length seldom exceeds 200 ft., the seismometers may be placed so as to cover this distance and still a considerable amount of cancellation will occur. In the limit, assuming purely erratic disturbances such as those due to wind and traffic, the cancellation effect will follow the well-known laws of probability and will be a function of the square root of the number of seismometers. In the case of eight seismometers the factor would be 3, which is still a very considerable factor; in fact, ample to make an unusable record a usable one. It also should be noted that, as the limiting sensitivity is determined not by the instrument sensitivity but by the disturbance level, there should result a decrease in the size of charges used.

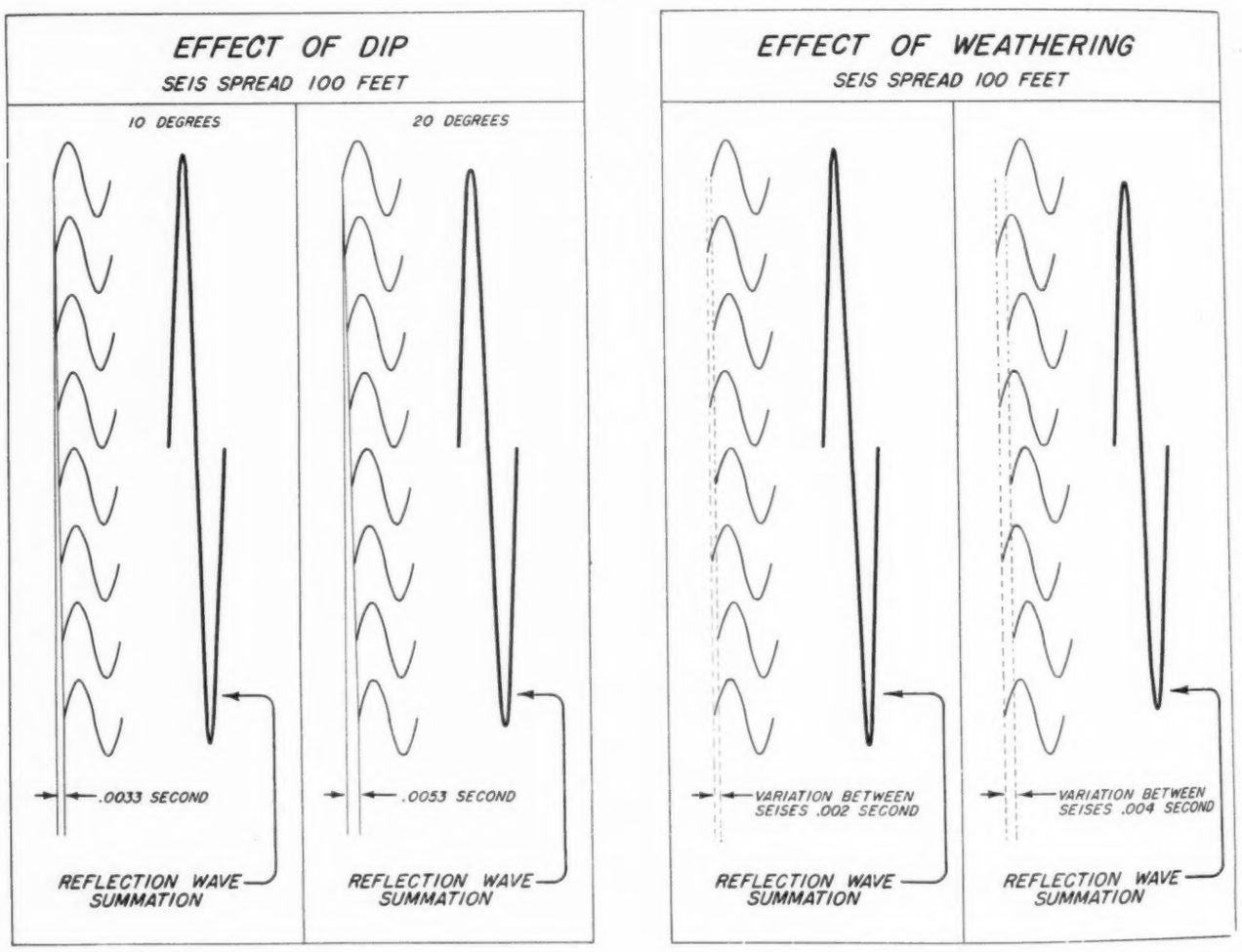
On the right side of Fig. 2 the two summations shown are for seismometer spreads of 100 ft. and 300 feet. Even in the case of the 300-ft. spread the reflection summation is still considerable. This spread is much more than is ever required.

In Fig. 3 on the left is shown the effect of 10-deg. and 20-deg. dips for seismometer spreads of 100 feet. If the dip should become greater it would be necessary to shorten the seismometer interval; however, 20-deg. dips are not found very frequently.

The effect of variations of the thickness or velocity of the weathering layer, the near-surface layer, is shown in the right half of Fig. 3. A variation of 0.004 sec. between adjacent seismometers is shown at the extreme right. Even this variation, which is most abnormally large, does not affect seriously the reflection summation. A variation of 0.002 sec., which from experience, with seismometers on the surface and not buried, is still abnormal, results in a close to 100 percent summation. In this discussion but one group of seismometers has been considered. In actual field practice six or more groups of seismometers would be photographed on the same record.

Therefore, it seems safe to conclude that the use of eight seismometers in multiple will, under conditions generally encountered in the field, result in a factor of discrimination between reflections and undesirable waves amounting to at least three. In some instances, where the wave length of the ground wave may be determined, the factor may be larger than this. This easily could mean the difference between a usable and an unusable record.

Fig. 3



Instruments and Operating Procedure in Geophysical Prospecting by Gravity Methods » » » »

By G. STUBBE* and K. H. SCHMIDT*

STRUCTURAL conditions such as anticlines, synclines, and faults cause anomalous conditions in the normal gravitational field by effecting either a mass excess or deficiency, and this fact makes the geophysical method of gravity prospecting possible. The same effect results from a mass of material whose density is sufficiently different from its limiting elements, as in the case of a salt dome.

These anomalous conditions may be found and evaluated by a number of different types of instruments, but changes in the force of gravity over a limited area is the fundamental fact that makes this possible for all.

Instruments such as the pendulum and gravimeter delineate irregularities by observing the difference in the total gravitational field while an instrument such as the torsion balance performs the same operation by measuring the rate of change of the horizontal component of gravity.

Torsion Balance. The oldest instrument and that still most used for the determination of the irregularities of gravity and their corresponding structural features, is the torsion balance. This implement was first designed by Baron Von Eötvös in 1880 and it was he, and his assistants, who first suggested its geological applications. This instrument measures the rate of change of the horizontal component of the gravitational field and conditions of curvature.

The working principle of the torsion balance is that a balance beam, suspended by a very fine wire and loaded with weights at its extremities, will be caused by the curvature of the planes of gravity to rotate until the force of gravity is balanced by the torsional resistance of the wire by which it is suspended. The two weights are displaced both horizontally and vertically from their common center of gravity as shown in Fig. 1. The reason for this is as follows: at any particular station the magnitude and direction of the force of gravity is constant, and by having the masses so displaced, when they are pointed in different directions, the torque produced in the suspension wire will vary and the position of equilibrium of the beam with relation to the case will vary correspondingly. From the constants of the instrument, in conjunction with observations of the position of rest of the balance beam, it is possible to calculate the direction and steepness of the gradient of gravitation at the point of observation, as well as certain dimensions whereby the curvature of the gravitation plane is determined. A single beam would require five different azimuthal observations for the above computations, so it is customary to equip modern instruments with two balance beams which reduces the required number of azimuths to three.

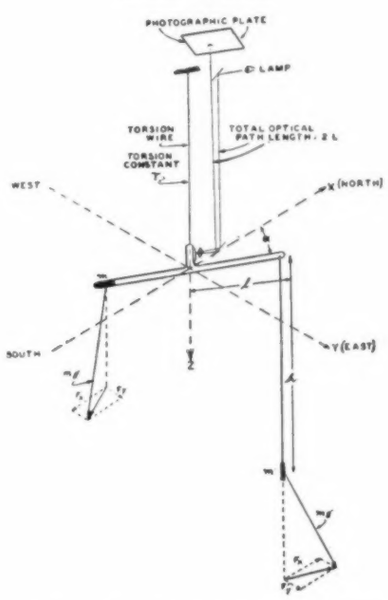
The large Eötvös-Schweydar torsion balance was the first to incorporate the decided advantages of photographic recording and a clock-work mechanism for changing the positions of azimuth, thereby making its operation entirely automatic. The instrument is composed of three parts, the base, which is used to obtain the correct height; the middle part, which contains azimuth stops and the clockwork mechanism; and the superstructure, which is the torsion balance proper. Other details such as the light circuit and beam arrangement are similar to those shown in the crossection of the Z-beam type.

The large type instrument described has an effective sensitivity of about 0.92×10^{-9} cgs. units per 0.01 cm. deflection on the photographic plate.

When using the torsion balance in difficult territory it was found imperative to design a smaller and lighter instrument, and above all to shorten the time required to take a reading at each station. Since the first appearance of the large type instrument two improved types have been forthcoming. A cross-section of the first is shown in Fig. 3, and is known as the Z-type torsion balance. The name is derived from the shape of beam adopted. This improvement in design materially reduced the size of the instrument and cut the time necessary for a set of observations from three, to two hours. In spite of this reduction in time the sensitivity of the instrument was not materially reduced. (1.2×10^{-9} cgs. per 0.01 cm. deflection.)

The latest improved type torsion balance is known as the inclined beam torsion balance. This instrument was a result of continued effort to meet the demands of the field man for equipment that not only was more portable but also required less time to make a station. By adopting the beam design shown in Fig. 4 the time of observation necessary in one azimuth was reduced to 20 minutes. Two further changes also were incorporated, namely, the clockwork mechanism that moved the photoplate on the top of the older types has been eliminated and instead movable mirrors have been provided coupled with the rotation of the balance, and the clamping mechanism has been much simplified. The sensitivity of this instrument is still sufficient for all practical geogravimetric investigations. (effec. sensitivity of

Fig. 1. Working principle of torsion balance



*American Askania Corporation, Houston, Texas.

1.5×10^{-9} cgs. per 0.01 cm. deflection on photoplate.)

Since the torsion balance is so widely used a short description of field procedure and a method for calculating a plate will be given.

Field Procedure. The choosing of

Fig. 2. Askania inclined beam torsion balance in field use

a torsion balance station must be done with care so as to minimize terrain effects. Nearby mounds and gulleys especially should be avoided. After once having chosen a site it may be necessary to level the station, although in areas such as the Gulf Coast it may suffice to obtain the configuration of the station by means of a level survey. A number of different methods are in use but here only the fact that topography must be corrected for will be mentioned.

The instrument is then placed on the station, oriented, leveled, and the beams released. After sufficient time has elapsed for the required number of observations, and the desired number of check positions, the beams are clamped and the instrument is ready to be moved to the next station.

Computation of Data. Figure 5-a shows a three-position torsion balance plate (inclined beam type) placed on a graduated reading glass, in reading position. The key is as follows:

B_1 = position of beam one
F_1 = fixed line for beam one
F_2 = fixed line for beam two
B_2 = position of beam two
T = temperature curve
O = fixed line and temperature dots used for orientation of the plate on reading glass
1, 2, 3, 1 = record of position of beams in the azimuths of 0 deg., 120 deg., 240 deg., 0 deg., respectively.

After orienting the fixed line of balance one the position of beam one is recorded by reading from left to right on the graduated glass and these readings entered in a computation form under the heading N_t, as shown in Fig. 5-b. The fixed line of beam two is then oriented in the same manner and the reading recorded. Inasmuch as only the variation in the beam positions is of interest the plate may be placed in any convenient position on the reading glass.

The calculation forms vary considerably, but the one shown involves all that is necessary for ordinary computation of the plate. Of course, corrections must be taken into account after the observed value of gradient and curvature have been obtained, but this is an individual problem. Noting that:

p = position of instrument, 1 = 0 deg., 2 = 120 deg., etc.
N_t = corresponding position of beam as read off plate.
N = original reading corrected for temperature. If the second observation of the first position does not check with the first it is customary to assume a straight line temperature effect and correct for this as shown in the calculations for balance two
N_o = the sum of $N_{1, 2, 3}$ divided by 3. This is the torsionless position of the beam

The remainder of the calculations are self-explanatory by inspection of the form. It may be stated that the various constants indicated as C_1, C_2, C_3, and C_4, are those supplied by the manufacturers of instruments for that particular beam system and component of gravity.

Gravimeters. Gravimeters are the newest device used for gravity prospecting. While various designs have been forthcoming most of them consist essentially of a mass suspended by a spring. The action of the instrument is to weigh this mass at different locations, thereby indicating relative gravity from station to station. If the gravimeter is set up at different locations on a traverse across a salt dome the readings of the indicating scale would be different at every station because not only is the weight of the mass in the instrument affected by the total mass of the earth but also by the density of the subsurface structure, which may act, as initially pointed out, as a mass excess or deficiency and

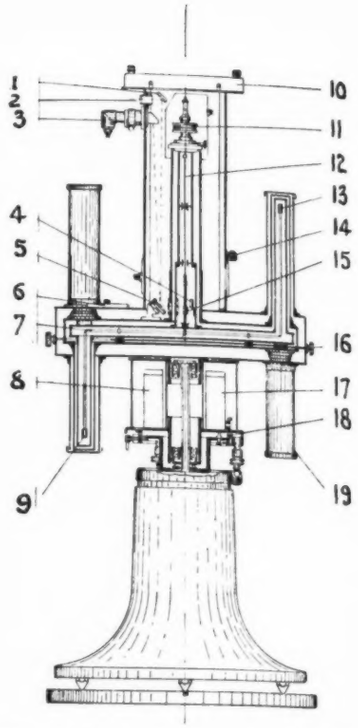
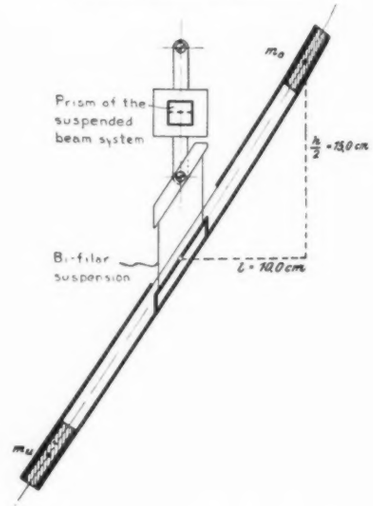


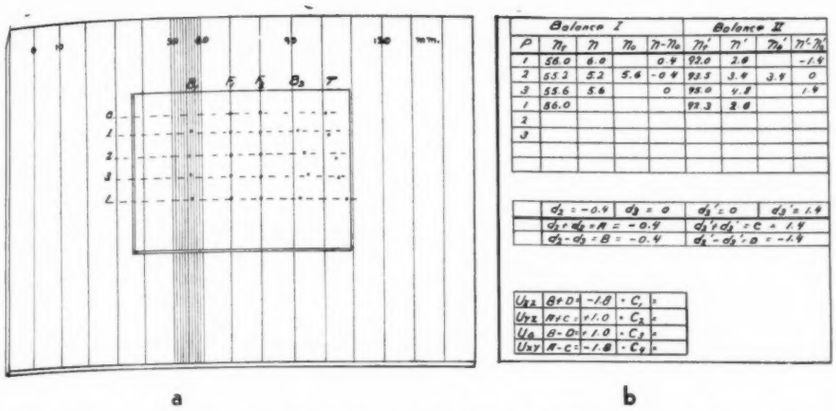
Fig. 3. Z-beam torsison balance shown in section. (1/14 actual size). (1) Interception mirror; (2) Scale; (3) Lamp; (4) Fixed mirror; (5) Adjustable mirror; (6) Compass; (7) Balance beam; (8) Contact clockwork; (9) Lower weight; (10) Plate-holder attachment; (11) Torsion head; (12) Platinum wire; (13) Upper weight; (14) Level; (15) Balance beam mirror; (16) Arresting mechanism; (17) Driving clockwork; (18) Azimuth ring; (19) Protective tube

thereby cause an anomalous condition in the gravitational field.

In designing an instrument with sufficient sensitivity to measure changes in gravity due to structures of geophysical interest, many complications

Fig. 4. Beam suspension in inclined beam torsion balance





a

Balance I					Balance II			
P	π_p	π	π_o	$\pi-\pi_o$	π_p'	π'	π_o'	$\pi'-\pi_o'$
1	56.0	6.0		0.4	93.0	2.8		-1.4
2	55.2	5.2	5.6	-0.4	93.5	3.4	3.4	0
3	55.6	5.6		0	95.0	4.8		1.4
1	56.0				93.3	2.8		
2								
3								

$d_2 = -0.4$	$d_3 = 0$	$d_3' = 0$	$d_2' = 1.4$
$d_1 = d_2 + A = -0.4$		$d_3' - d_2' = C = 1.4$	
$d_3 - d_2 = B = -0.4$		$d_3' - d_2' - 0 = -1.4$	

U_{12}	B+D	-1.8	C_1 =
U_{13}	A+C	+1.0	C_2 =
U_{23}	A-D	+1.0	C_3 =
U_{23}'	A-C	-1.8	C_4 =

b

Fig. 5. a. Three-position torsion balance plate (inclined beam type) placed on graduated reading glass, in reading position. b. Computation form for recording readings

arise. The most disturbing factor is the temperature effect, as changes in temperature alter the physical characteristics of the essential parts of the instrument quite materially, thereby falsifying the readings. Other disturbing factors, such as elevation, magnetic, and barometeric effects, more or less can be taken care of by careful field procedure and corrections.

Field Procedure. The gravimeter has the advantage of not being affected by nearby masses, hence the location of stations is more or less a matter of convenience. Elevations must be determined within an accuracy of one or two feet, as the force of gravity is a function of altitude.

Stations for this type survey usually are laid out in a network so that several checks may be obtained to determine the instrumental variations. The checking may be either a repetition of stations on different days, or another method as follows: If three stations a, b, and c are run and the difference between gravity at b and c is determined as well as the difference between a and b, and a and c, the sum of the differences should equal zero.

In setting up the instrument at a station it is essential that the level position be ascertained with as much accaccuracy as possible, for level errors introduce reading errors that vary with the design of the gravimeter being used. After the instrument has been leveled an observation of the change in position of equilibrium is observed, and the amount of change in whatever device may be used to bring the system back to the original position is recorded. The recorded change multiplied by a constant factor of the instrument gives the data desired, and no further computations are necessary other than the customary corrections.

Pendulum. The pendulum long has been recognized as a standard for the determination of the absolute force of gravity. This instrument depends upon the fact that changes in gravity will cause a change in the period of its oscillations.

One type of field apparatus is shown in Fig. 6. This is a three-pendulum instrument with the recording device also shown. The latest types developed are much superior to those formerly in use in that material such as invar and quartz are used, thereby cutting down considerably on the effects of temperature.

Stations of a field survey usually are run on a comparison basis with some base station. In this procedure a reference pendulum apparatus is set up at the base station and run simultaneously with the survey instruments. The comparison of changes in period of oscillation usually is done by the coincidence method. Pendulum work requires very elaborate apparatus, as it is necessary to transmit and record time signals with a good degree of accuracy.

Because of the long period of observation, as well as the amount of equipment and cost, the pendulum method is not popular for geophysical prospecting. Its value is in the determination of regional effects for exploration work and, of course, is unsurpassed for scientific work such as that performed by the government in its study of the distribution of gravity throughout the world.

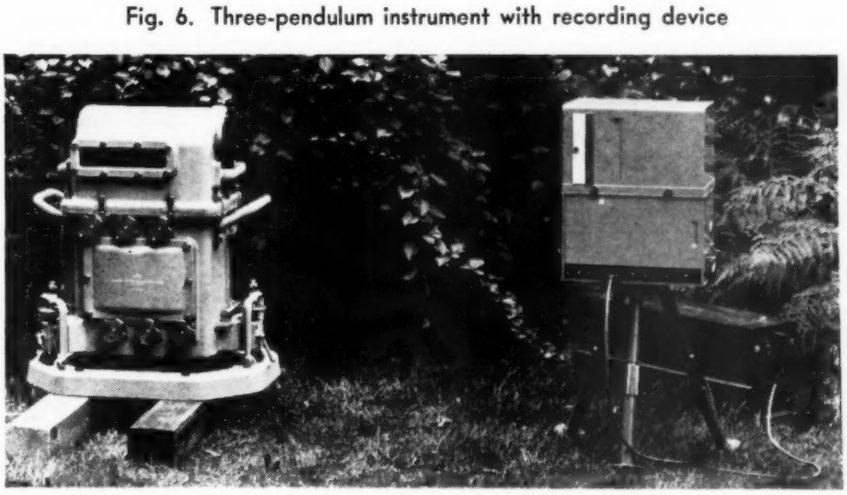
Gravity Summarized. At the present time the torsion balance is still the most practical and reliable instrument for detail gravimetric surveys. In addition to giving all the data available by other methods it has the advantage of sensitivity and stability of data obtained.

The gravimeter undoubtedly will become more practical and useful as further improvements and developments are forthcoming. At the present time it seems that its activities are limited to surveys of a reconnaissance nature.

The pendulum appartus will be limited to studies of large area and to work of scientific interest.

In comparing gravity surveys with other methods, such as the seismic and magnetic methods, it may be mentioned that a study of the activity in any particular field reveals a cyclic character. Whether one method or the other is used should not depend so much on whether one method may be popular at the time but rather upon the conditions that present themselves in the area to be surveyed. In fact, multiple methods of investigation should offer much and is becoming recognized as good exploration policy. The position of gravity surveys fits well into this picture, for the method is recognized to be valuable in broad, as well as detail, studies, and operating costs are not prohibitive.

Fig. 6. Three-pendulum instrument with recording device



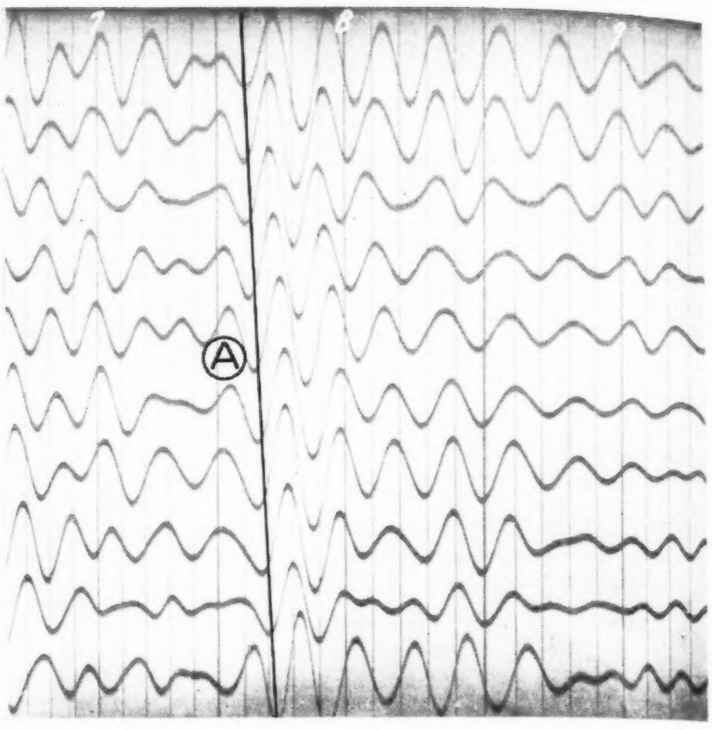


Fig. 1. A typical seismogram showing a reflection by means of the "line-up" of corresponding waves
(Rieber Laboratories)

By
FRANK RIEBER

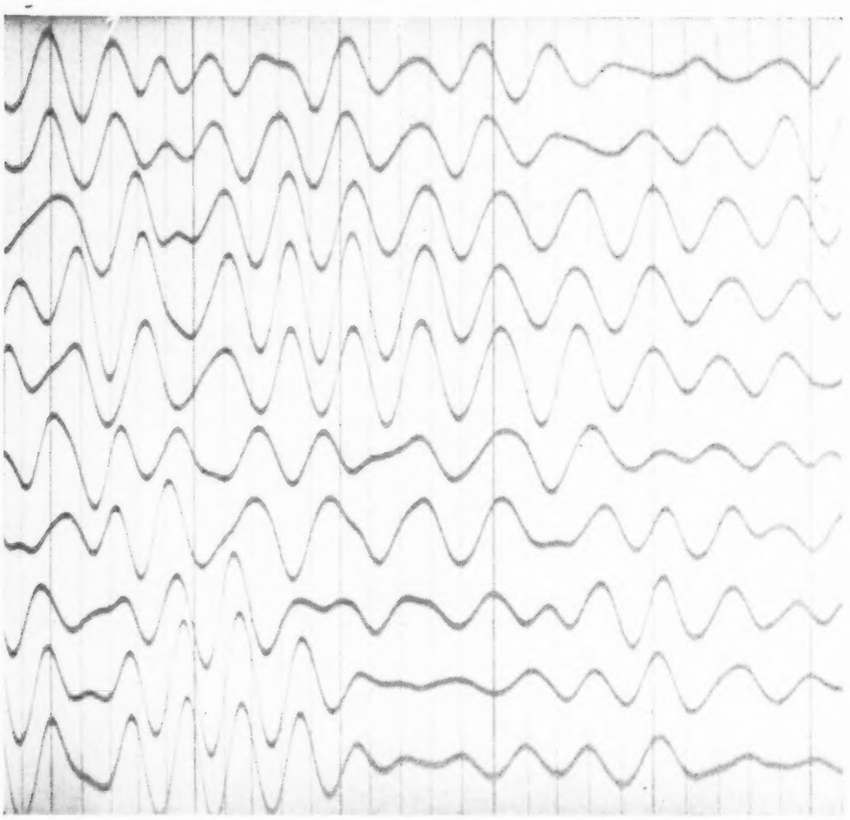
Applications of the Geo-Sonograph to Petroleum Exploration

SEISMIC geophysical exploration by the new Rieber Sonograph and Photo Electric Analyzer and operating methods is a recent development. In field practice with this device the many reflections sent back from complex structures are photographically recorded on ten separate sound tracks on a film.[2] When these are sorted out and transcribed by the photo electric analyzer it is possible to identify and use many reflections that otherwise would be impossible to recognize.

The device has been developed for the particular purpose of conducting exploration in regions where the ordinary reflection seismograph yields confused records. It is not limited to such use, however, and may be employed in routine exploration rapidly and satisfactorily.

At the time the development of the Sonograph first was undertaken, all reflection shooting was being done with the usual form of reflection seismograph. Such apparatus provides records in the form of wavy lines on a strip of bromide paper, which hereafter will be referred to as *visual* records to distinguish them from the more recently developed sonograph records. Reflected waves appear on such visual records as a well-recognized pattern. If there are ten individual traces on such a record and a reflection wave arrives at a time when no other motion of the earth is going on, this pattern will appear in a very simple, ideal form. Each of the traces will show a wave, and the waves will be similar to each other. Further, they will be arranged in a regular pattern so that it is possible to draw a relatively straight line across the records, passing through the crest of corresponding waves on each of the traces.

Such a pattern usually is referred to as a "good reflection", and may be used with certainty in reconstructing a cross-section of the earth from which the reflection was returned. A "line-up" of corresponding waves is marked



[1]Rieber Laboratories, Los Angeles, California.
[2]"New Geophysical Method Provides Reliable Data for Structure Mapping" by Wallace A. Sawdon—*The Petroleum Engineer*, October, 1936.

Fig. 2. A typical reflection seismogram in which the actual reflections are confused or lack a clear pattern
(Rieber Laboratories)

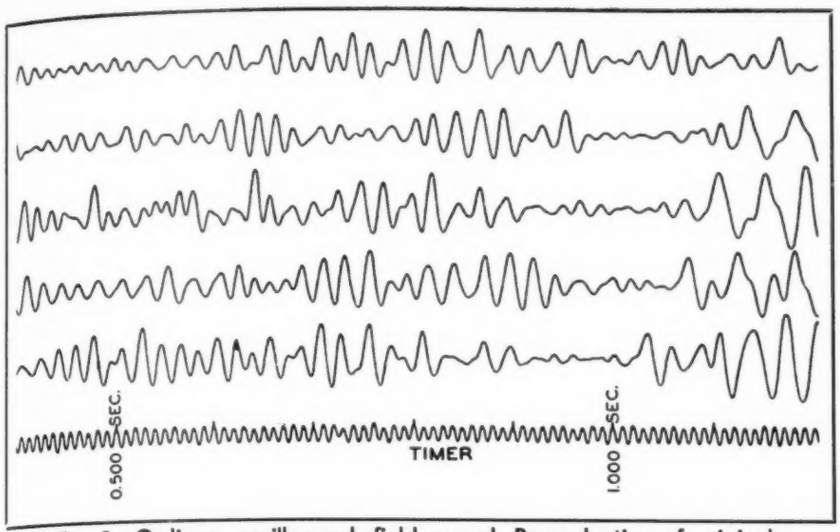


Fig. 3. Ordinary oscillograph field record. Reproduction of original film record

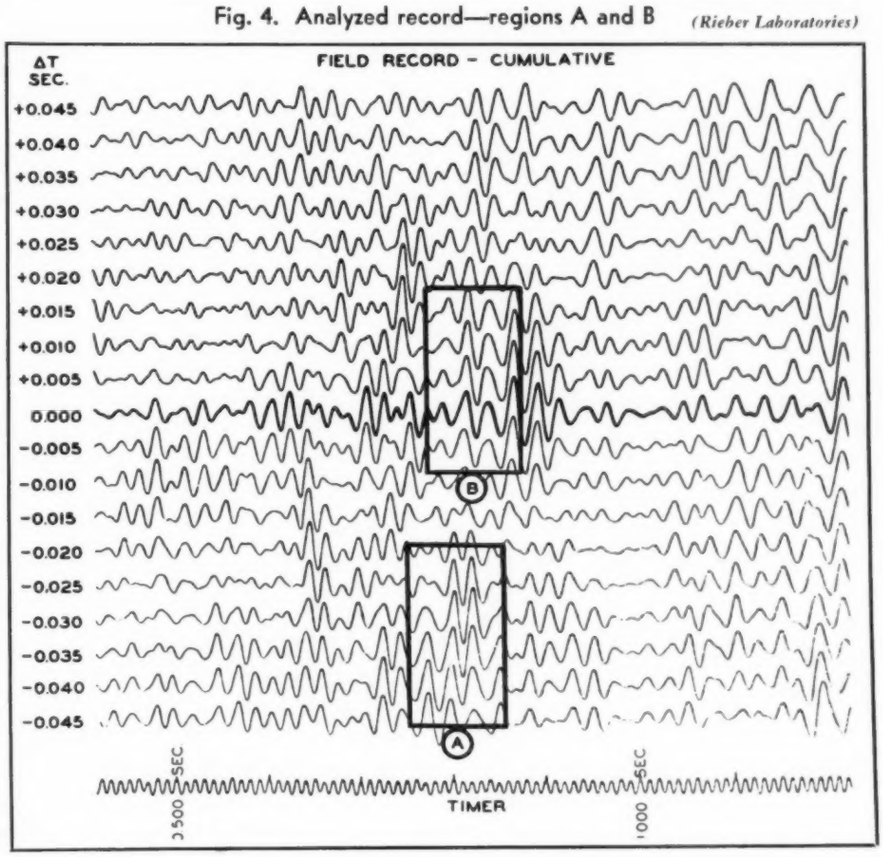
on this record (Fig. 1) and designated as A. Under good operating conditions and in favorable geological territory, successive patterns of this sort will be found on a visual record, extending over a total time of five or six seconds following a shot. Such a succession of reflected waves naturally is to be interpreted as arising from a succession of relatively conformable strata in the earth. Under unfavorable geological conditions, however, the visual record will show vibrations, big enough to be reflections, and lasting for five or six seconds on the record, but these vibrations will be highly confused and little or no evidence of regular reflection patterns will be seen (see Fig. 2). Such records are customarily marked "N.R", presumably meaning "No Reflections." It would seem that this assumption might require further examination before being accepted as a fact.

If it should develop that the confused vibrations on the later part of such a record are due not to the absence of reflections but to the presence of too many reflections, it is certain that we should not abandon too lightly the possibility of extracting such information as is contained in the confused portions of the wave trains. This is particularly true, for these confused records have an uncanny habit of turning up in places where they are least welcome. For example, they are more frequently found near the edges of valleys, where there are known possibilities for overlap and buttress sands, and where previous experience has taught us that we should continue to search for accumulation due to such causes, and similar to those fields that have produced so richly in the past. Confused records of this same sort are frequently found also in the vicinity of faults. In fact, their presence is sometimes taken *per se* as an indication of faulting. As a line of exploration proceeds across the country good records may be uniformly obtained except for a short section of the line, where everything is confusion. It is quite customary to mark such areas on the exploration map under the convenient and all-embracing title "broken-up region—probable faulting."

Some four years ago the Rieber Laboratories at Los Angeles undertook an investigation into the causes of confused reflection records. After several years of intensive work, the main source of the trouble was discovered to lie in the geological conditions beneath the surface. Certain types of structure, in brief, inevitably returned a complex crisscross pattern of waves to the surface, and these waves, reproduced on a visual record, could not be distinguished separately. This did not mean that the waves could not be separated and identified. It meant merely that the visual record was not the right approach to the problem. Consequently, further search was made for a new method of recording that would permit the separation and identification of a crisscross group of emerging reflections. Finally, a means for accomplishing this end was discovered. The old style of visual record, which, incidentally, has been used in all seismograph work from the earliest times, was abandoned. In its stead, the earth vibrations were recorded as sound track, on photgraphic film.

This sound track could not be read by the eye any better than the old visual record. If crisscross waves were recorded on such a film, their presence would be equally obscure to the human eye. The new form of record could, however, be passed through a special analyzing instrument, invented and developed for this express purpose. This analyzer was designed to separate and

Fig. 4. Analyzed record—regions A and B *(Rieber Laboratories)*



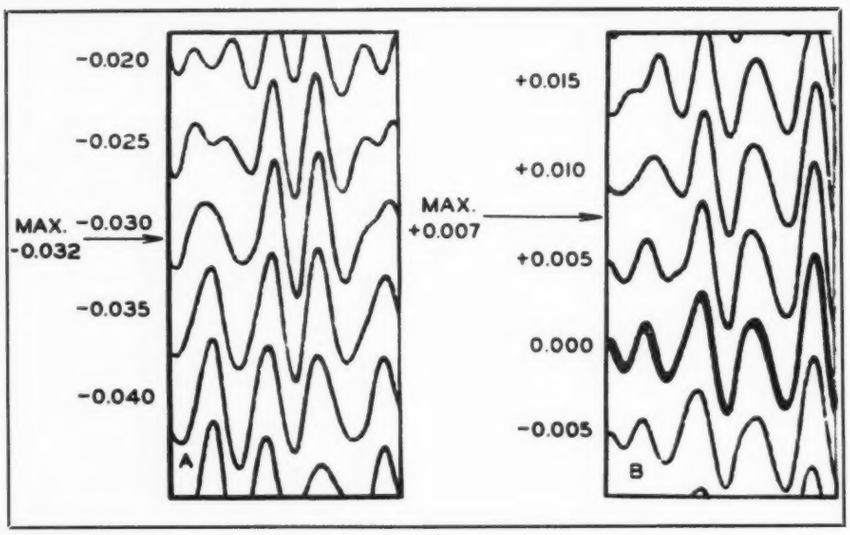


Fig. 5. Regions A and B enlarged
(Rieber Laboratories)

identify all individual waves in any crisscross pattern on the film. The combination of this sound track record and the analyzing instrument was a revolutionary step. Together with other accessory inventions, it now has been incorporated in a complete working system, which has been named the Rieber Sonograph.

The Sonograph Analyzer is a large revolving drum carrying a wide strip of paper upon which the machine makes a record in ink. The sonograph film taken in the field is introduced into a magazine on this analyzer, and threaded through the instrument, which is motor-driven and automatic. When in operation, the analyzer feeds the film slowly past an optical system and a photocell, which are set to respond principally to waves that reach the surface of the earth from one known direction only. These waves, naturally, are mixed on the film with many other waves from other directions. The analyzer, however, selects and records, as an inked line on the rotating drum, only the waves from the direction first chosen. Thereafter the instrument automatically rewinds the film for a fresh start, changes its internal optical setting to respond to a second known angle, different from the first, moves the recording pen over slightly, and repeats its cycle of operation. When completed, the analyzed record consists of a large number of individual traces, each of which represents vibrations arriving from some one definite direction in the earth.

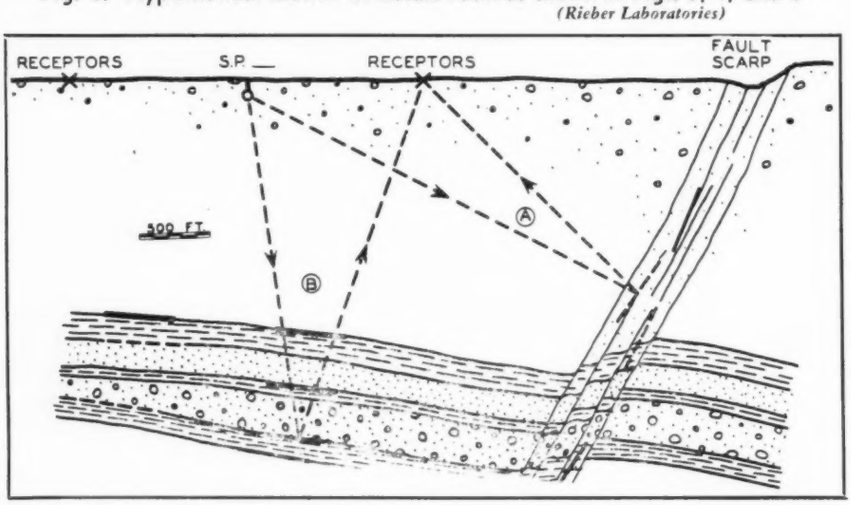
The various waves contained on an analyzed record are selected and marked. Pencil lines across the record indicate the times when various component waves arrived. By means of a pair of dividers, or by eye alone if the operator is sufficiently skillful, a selection is made between the adjacent analyzer traces, and that on which any given wave appears at its maximum amplitude is chosen as representing the true direction of arrival.

A specific illustration of the performance of the analyzer may prove of interest. For this purpose, a region was chosen in which the ordinary seismograph type of visual record gave no usable information. Sonograph films, incidentally, always can be reproduced in the seismograph form if desired, for comparison. Therefore, in the region in question, Fig. 3 has been reproduced from an original film record, but in the form of the ordinary type of visual record common to reflection seismographs. It will be observed there is no clear evidence of patterns of any sort on this record.

The analyzed record for the same shot point, on which the regions A and B have been marked as designating two of the arriving wave trains, is shown by Fig. 4. Other wave trains of course, are visible throughout the analyzed record, but these two only have been selected to avoid confusion.

The same regions, A and B, enlarged, are shown by Fig. 5. The figures on the left of each section indicate the time difference between the arrival of the waves at the first and last receptor in the series, from which figure the angle of arrival of the wave may be determined. To read such a record, the amplitude of a corresponding wave on each of the successive traces is noted, and the trace at which the wave reaches a maximum amplitude is selected. Opposite this trace, the scale figure of differential time is selected and from it the angle of arrival computed. This change of magnitude on successive traces is so regular that it is not necessary in practice to select some one trace as representing the maximum value. Readings can be conveniently interpolated between the traces as is shown by the arrows on Fig. 6. Interpolated value appears opposite the arrow. The result of this process is that angles of arrival may be determined within the very narrow limits, even for a mixture of waves arriving from many angles at the same time.

Fig. 6. Hypothetical section of actual records shown in Figs. 3, 4, and 5
(Rieber Laboratories)



The actual records shown in Figs. 3, 4, and 5 are part of a series from which the hypothetical section shown in Fig. 6 was mapped. The position of the simultaneously arriving waves A and B shown on Figs. 4 and 5 is indicated by the dotted lines on Fig. 6.

Summing up the conclusions to be drawn from this illustration, it will be seen that an analyzed record was able to separate out a large number of different waves, among which those designated as A and B are selected for illustration. As they appear on the section, it is quite evident that wave A proceeds from a fault, and wave B from a stratum, and that neither could have been distinguished without the aid of the analyzed record.

Prospecting for Oil Structures By Electrical Methods

By J. J. JAKOSKY[1] and C. H. WILSON[2]

THIS article describes a new electrical method for oil exploration and discusses briefly results recently obtained in the field work. Part A, dealing with apparatus and theory of operation, is by the first-named author, and Part B, dealing with field results, by the second author.

PART A

Development History. The electrical method employed in this work is an outgrowth of considerable early work in the application of the conventional resistivity methods to placer and lode mining, and water-supply problems. The fundamentals of these methods are well-known,[3] and briefly may be described as follows: The resistivity of the subsurface is determined by passing an electric current between two electrodes, and the depth of penetration is governed largely by the separation between the two electrodes.

[1]Technical Director, International Geophysics Company, Los Angeles, California.
[2]Chief of Field Operations, International Geophysics Company, Los Angeles, California.
[3]Frank Wenner: "A Method of Measuring Earth Resistivity," U. S. Bureau of Standards, Vol. 12, 1916.

Factors Influencing Flow of Electric Current Through Rocks. When an electric current flows through the earth, certain electrochemical phenomena occur. When two electrodes are placed in contact with moist earth comprising the earth's surface, they form, in effect, a galvanic cell. The flow of electricity through the subsurface rock material included between the two electrodes is by means of electrolytic conduction. The current is carried by the natural "moisture" in the subsurface, which is an electrolyte consisting of water solutions of various soluble mineral salts contained within the rock. The factors affecting the conduction are those that affect electrolytic conduction in general, although the effects of these factors may be modified somewhat by the artificial conditions imposed by such rocks. The electric current is conducted by the transfer of ions through the solution, the electrical conductivity increasing with an increase in ionization. These ions in part may be those of the solvent itself, but mainly are the ions formed by dissolution of the soluble salts. Dissolution increases with rising temperature, often very rapidly over the lower range of temperature with a resultant increase in electrical conductivity. Interpretation of the data therefore must take into account the vertical and lateral subsurface distribution of ground waters and their variation in chemical content, as well as variations in subsurface temperatures. The potential drop through the electrolyte is not in accordance with the ohmic drop that normally would occur in a metallic conductor. This potential usually is greater than would be predicted by Ohm's law, and this increased increment of potential sometimes is referred to in the literature as "polarization," or "overload" potential. This increased potential is due largely to a redistribution of ions when current flows, and varies with the density of the current.

As a general rule, the relationship between current and potential is exponential, and unfortunately is not a constant for all subsurface materials. The subsurface current distribution

Illustrating resistivity variations in different areas

Fig. 1. California

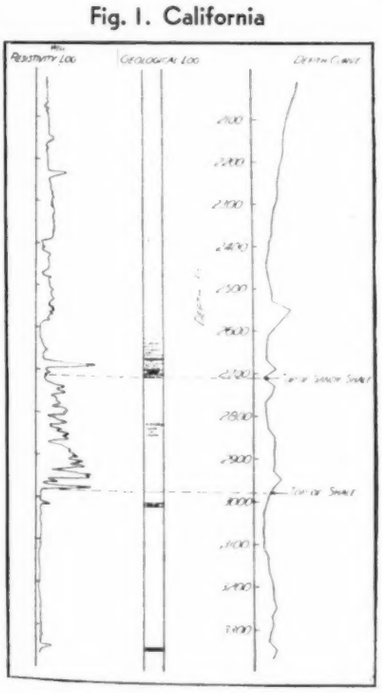


Fig. 2. New Mexico

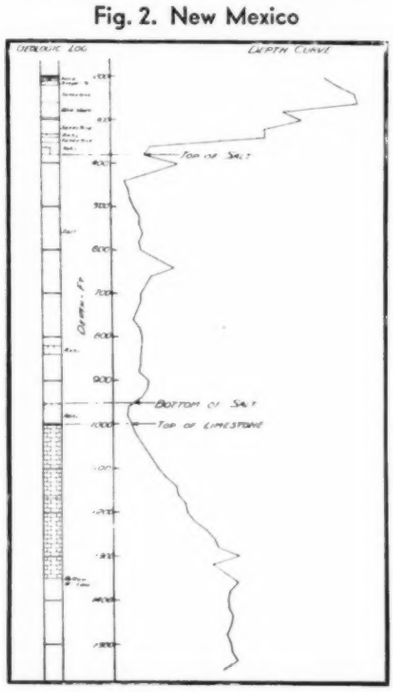
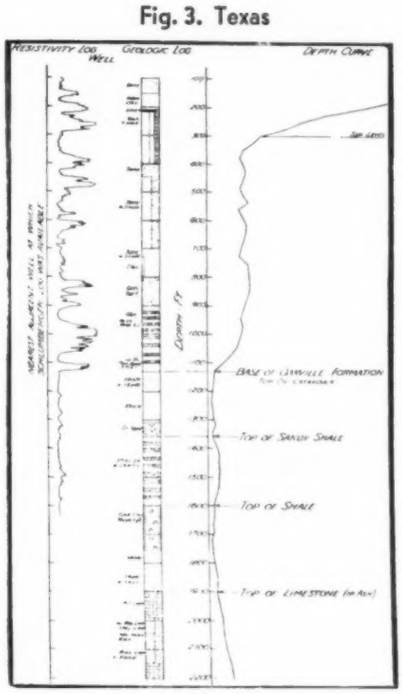


Fig. 3. Texas



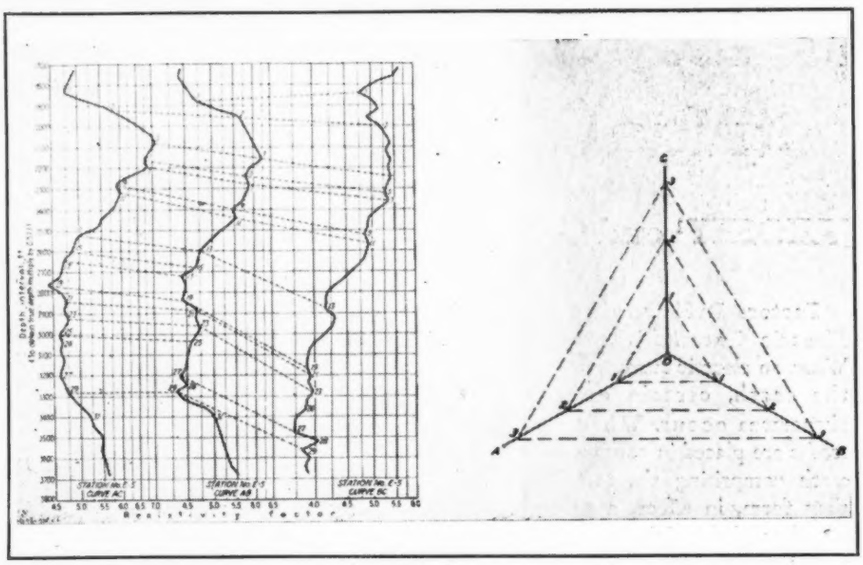


Fig. 4. Electrical curves, tri-directional system of surface measurements

therefore is influenced to a large extent by the density of current per unit volume of material. An unknown variable therefore is introduced, and it has been found that the most practical method of minimizing this variable is to maintain a constant density of current per unit volume of material, or systematically to vary that current as the volume of material varies.[4]

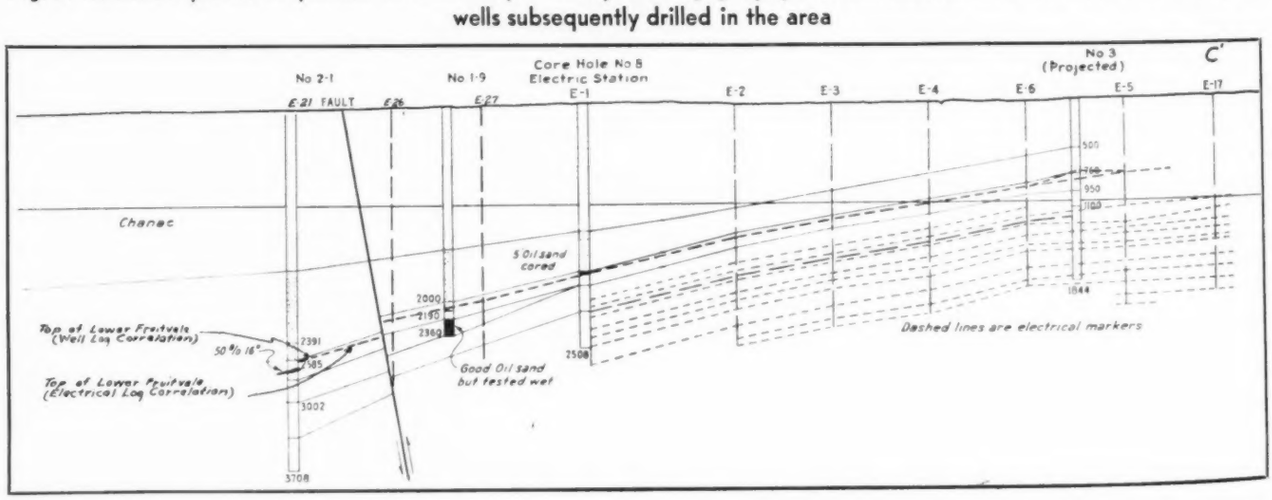
The distribution of subsurface moisture, and the nature of the salts dissolved in this moisture, vary with the stratification. In some areas this distribution is uniform for considerable distances in a lateral direction. This is notably true in the Mid-Continent area where electrolytic conditions are uniform over many miles of area. In California, however, electrolytic conditions change rapidly laterally. This is especially noticeable in formations of recent geologic age, which generally are loosely consolidated and non-uniform in lithologic character. In much of California's oil-producing areas, the geologic section is characterized by lens-shaped beds, with considerable variation in thickness. In such areas, the separation between the electrical stations must be relatively small (1000 to 2000 ft.) if it is desired to carry certain markers, or "phantom horizons," from one station to another. In areas where uniform conditions exist, as in the Mid-Continent, the stations may be placed distances of a mile or more apart, with clear correlation between stations. The cost of exploration varies, of course, with the number of stations required to give the necessary information.

It is well recognized that the conductivity of practically all non-metallic materials comprising the earth's crust is very low when these materials are dry, and that their conductivity is a function of: (1) the percentage of moisture disseminated through the materials, (2) chemical properties and ionization factors of the soluble salt in the material, and (3) the nature of the rock material itself. Of these factors, the percentage of moisture usually is of most importance in actual field work. For those rocks or rock materials containing high percentages of soluble salts, a critical point has been found to exist in the relationship between resistivity and percent moisture. This point generally is in the neighborhood of about 10 to 15 percent moisture. For greater amounts of moisture content the curves giving the relationship between percent moisture and resistivity are relatively flat with small changes in value, while below this percentage the resistivity values increase sharply. Materials containing fresh waters that are low in salt content (sandstone, limestone, and the leached gouges) have higher resistivity values and do not exhibit sharp changes in resistivity as the percentage of moisture changes. This effect of moisture content on electrical resistivity is one of the chief factors influencing field work.

Another factor influencing electrical studies is the variation in resistivity with time of current flow. Electrolytic effects again are responsible for this variable. It has been found that the resistivity varies with the time during which the current flows through the subsurface. Accuracy of field measurements therefore requires that the current be applied for a definite period of time, in addition to the application of a known density of current to a given volume of material. It

[4]U. S. and foreign patents pending, by J. J. Jakosky, covering methods, field technique, and apparatus.

Fig. 5. Structure profile of portion of San Joaquin Valley showing geophysical correlations and the close relationship to wells subsequently drilled in the area



also has been demonstrated clearly that the most consistent results are obtained by having the current flow for a relatively short period of time.[5] The results are more consistent because (a) the measurements are reproducible with greater accuracy and (b) greater differences in apparent resistivities are obtained for different lithological sections.

In applying this electrical method, current is passed into the ground between two sets of electrodes and electrical or magnetic measurements are made to determine the current distribution within the earth.[6] Since the depth of penetration is governed by the separation between the two electrodes, the ultimate theoretical depth range is governed only by the distance that the surface electrodes may be separated. The penetration depends upon the relative conductivities of the various materials comprising the subsurface, and this depth of penetration varies from 25 to 35 percent of the distance between the two electrodes. In a major portion of the field work, the subsurface structure is being mapped at depths of 4000 to 5000 feet.

[5]U. S. Patent No. 2,015,401, J. J. Jakosky, "Method for Determining Underground Structure," filed May, 1933, issued September, 1935.

[6]U. S. Patent No. 1,906,271, J. J. Jakosky, "Method and Apparatus for Determining Underground Structure," filed June, 1931, issued May, 1933.

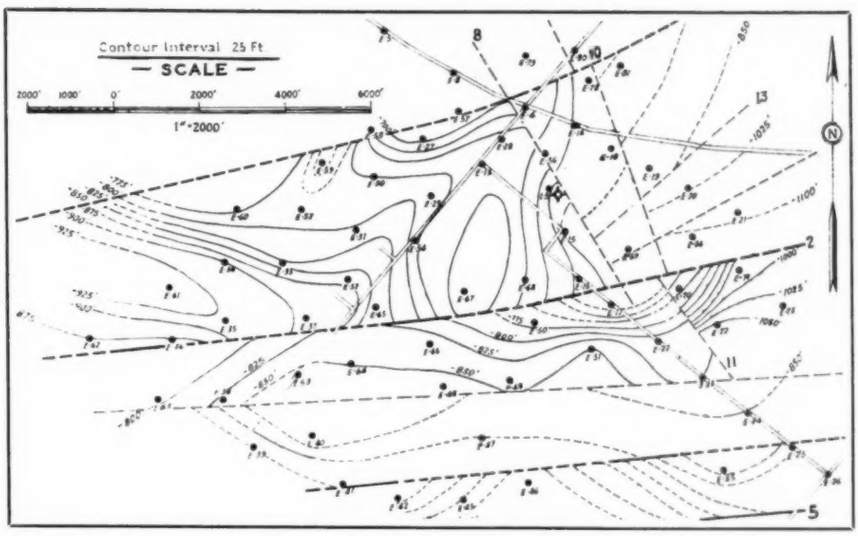
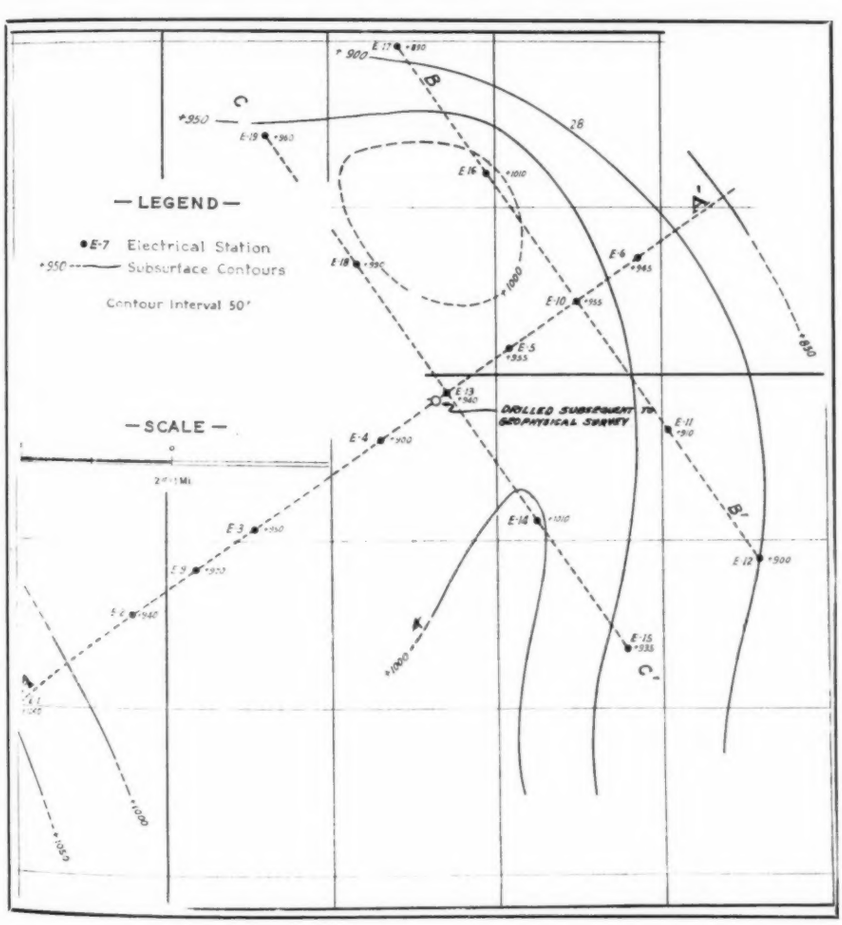


Fig. 6. Fault locations and subsurface structure contours determined by an electrical geophysical survey

Fig. 7. The results of electrical work, showing subsurface contours on the base of the salt, Goliad County, Texas

Probable fault—subsurface trace
Possible fault—subsurface trace
Sub-surface contours on base of Oakville formation



Presentation of Field Data. Various arrangements may be employed for showing the relationship between current distribution and depth of penetration. During reconnaissance and for immediate field use, a non-mathematical analysis is employed since it is the simplest and most direct arrangement showing the depth of penetration versus the changes in current distribution. Curves usually are plotted with current variations as abscissae and depth, in a downward direction, as ordinate. This curve is termed an electrical log. One or more of these electrical logs are obtained for each electrical station. Interpretation of the data in a given area is made by analysis of the electrical logs at each station, and by correlation of corresponding points of inflection on each of the curves of the various stations. The sharpness, i.e., variations in rate of change or the differences between maximum and minimum points on the curve, depends upon the relative distribution of the current in the various strata. As previously discussed, materials containing a percentage of moisture greater than 10 to 15 percent, have relatively small differences in resistivity for changes in moisture content. This is to be expected, since all curves are asymptotic to the resistivity of the electrolyte itself.

Resistivity variations in different

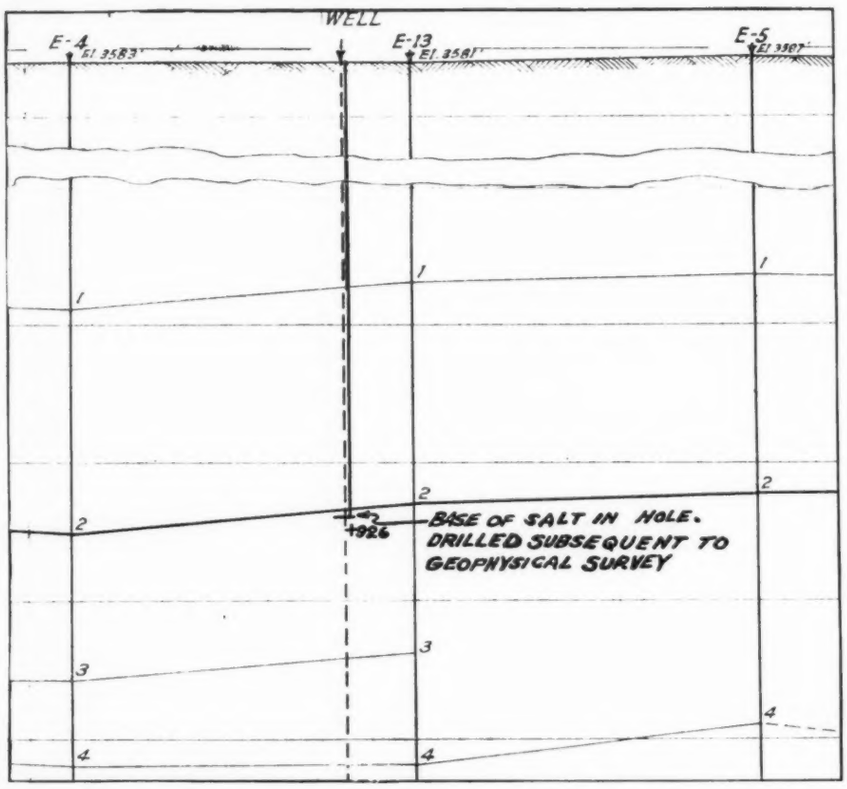


Fig. 8. Portion of a structure profile determined by electrical methods (See Fig. 7)

areas may be illustrated by reference to Figs. 1, 2, and 3. Fig. 1 is quite representative of the California areas, which are perhaps the least resistive of any of the areas worked in to date, and contain materials of more recent geologic age having large percentages of moisture content. Practically all the California curves possess relatively small changes electrically, corresponding to the minor changes lithologically. Fig. 2 illustrates representative New Mexico curves where very abrupt electrical changes are found, which are in accord with the wide variations occurring lithologically in that region. In the Texas area the changes, Fig. 3, are intermediate between the first-mentioned areas, and again in accordance with the general stratigraphic variations.

Correlation of Field Data. Analysis of data from the various stations may proceed in a manner similar to that employed in correlating the familiar Schlumberger electrical well logs. Corresponding points of inflection are marked on each curve, and by plotting the elevations of these points the subsurface structure may be determined. The measurements made at the surface of the ground give a summation of effects and as ordinarily plotted will not contain the minute detail of the electrical logs made within the well, but the major structural breaks will be present and generally may be correlated with the same breaks on electrical-well-log curves available.

Systems of Field Measurement. Measurements may be made along a line extending in a single direction on each side of the station point. This type of measurement is termed a unidirectional measurement, and the electrodes are progressively moved outward in order to give an increasingly greater depth of penetration. A single electrical log curve is obtained from this series of measurements.

An important type of measurement utilizes a tri-directional system. The three lines of measurement are laid out 120 deg. apart (in the shape of a Y) as shown in Fig. 4, and points equidistant from the station are labeled correspondingly as A-1 and B-1. Current is then passed into the ground between each pair of corresponding points, thereby giving three complete measurements at that definite distance from the central station. This procedure is repeated for various distances, and three complete electrical logs are obtained simultaneously. By this arrangement the near-surface effects are properly evaluated, and suitable corrections are made for topography and the anisotropic properties of the strata. Various modifications of this procedure are employed, the choice being governed by local conditions. Analysis of the tri-directional data of a station allows immediate determination of the dip and strike of the strata at different depths, and also indicates any changes in dip and strike due to thickening of beds or unconformities. Three electrical logs obtained from a station in the San Joaquin Valley, California, are plotted in Fig. 4. Corresponding points of inflection are connected by means of dotted lines, as shown. Change in dip and thickening of section are indicated clearly by the curves. The dip and strike at different depths may be determined by use of the conventional three-point method. This field procedure is used extensively as a reconnaissance method in the work.

Fault Traverses. Problems involv-

TABLE I

SAN JOAQUIN VALLEY AREA

Comparison of Geophysical Results to Drill Hole Data

Core Hole or Well No.	Nearest Adjacent Electrical Station	Depth to top of lower Fruitvale Zone—feet		
		Well or Core Hole	Feet Electrical Station	Interpolated to Well or Core Hole Location
No. 1	E-21	2585	2610	2610
No. 2	E- 1	1730	1740	1740
No. 3	E- 5	760	765	750
No. 4	E-29	2554	2620	2595
No. 5	E-55	2408	2460	2430
No. 1-9	E-27	2040	2060	2090

Location of electrical stations with reference to well or core hole and in accordance with indicated structure.

E-21 At No. 1 well
E- 1 At No. 2 well
E- 5 Approximately 1400 ft. east of, and down from, No. 4 well
E-29 Approximately 300 ft. north of, and down dip from, No. 4 well
E-55 Approximately 200 ft. west of, and down dip from, No. 5 well
E-27 Approximately 300 ft. southeast of, and up dip from, core hole No. 1-9

ing the location of buried contacts and faults usually are solved by some type of line traverse. In work of this type, measurements are made along a traverse that extends across the area where the fault or other discontinuity is expected. Faults and fault zones are indicated sharply in this type of traverse since they are zones of better electrical conductivity. The material in the fault is broken or disturbed and contains a greater percentage of moisture than the original undisturbed sedimentary beds. In addition, the electrical gradient of the strata on each side of the fault is different where an appreciable displacement has taken place.

PART B

In the majority of cases the method has been employed: (1) in areas covered by deep overburden or alluvium, (2) in swampy areas, tide lands, etc., and (3) in faulted areas. It has been successfully applied under each of the above conditions, where the presence of extensive salt beds and variations in the overlying unconsolidated sediments have made difficult the successful application of geophysical methods.

Here are presented the results obtained under a wide range of geological conditions, and data illustrating actual application of the independent electrical techniques discussed in the forepart of this article.

San Joaquin Valley, California. Electrical geophysical studies were conducted approximately 25 square miles lying near the southern end of San Joaquin Valley, adjacent to the southern foothills in Kern County, California.

Fig. 5 is a structure profile along line C-C′ in this area showing the geophysical correlations and the close relationships to wells subsequently drilled in this area.

Table 1 is a tabulation and comparison of the geophysical results and information disclosed by subsequent drilling. As shown by this table, the predicted geophysical results agree very closely with the actual conditions as determined by data from six wells or drill holes, four of which were drilled subsequent to completion of the geophysical survey.

Karnes-Goliad Counties, South Texas. This survey conducted during the past year illustrates the application of the method in a faulted area the faulting of which is complex. Fig. 6 shows a portion of the area with fault locations and subsurface structure contours determined entirely by the electrical geophysical survey.

The work in this area was primarily that of fault location. Preliminary study was therefore conducted by means of electrical traverses across the area. After location of the faults, detailed structure mapping was conducted by means of stations located adjacent to the faults. Subsurface structure contours were plotted from correlations of electrical logs obtained at the various stations. (Fig. 6).

The results of electrical work in a portion of this general area are shown in Figs. 7 and 8, which show, respectively, subsurface contours on the base of the salt, and a structure profile along line A-A′.

The electrical work was employed here to determine the existence of a possible structural high along the line of the traverse. No such structure was indicated and subsequent drilling by other operators not only confirmed this fact but determined the base of the salt at a depth within 20 ft. of the indicated electrical depth.

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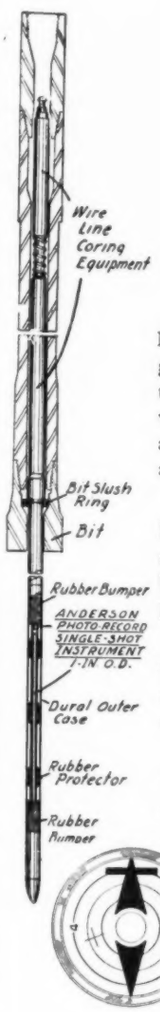
OF DRILLING WELLS



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For Measuring both Direction and Inclination photographically in open hole. These instruments provide the survey data on which direction control of a drilling well is based. Sizes from 3¼" O.D. to 1½" O.D.—all with Interchangeable Inclination Units for accurate and easy reading.

With Wire Line Coring Equipment

By using the Small Photo-Record Single-Shot with any make wire line coring equipment, readings can be taken through and below the drill bit without pulling the tools out of the hole.

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This Deflecting Tool is oriented into the hole with the patented Anderson Method of Orientation and will start the hole toward a predetermined objective.

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ANDERSON BITS

Specially designed to facilitate directional drilling operations.

To the left is shown the Small Anderson Photo-Record Single-Shot as used with wire line coring equipment. This Disc shows four degree circles. Direction is read with an Anderson reader.

Above: The Lewis Knuckle Joint

Right: The Kinzbach Whipstock.

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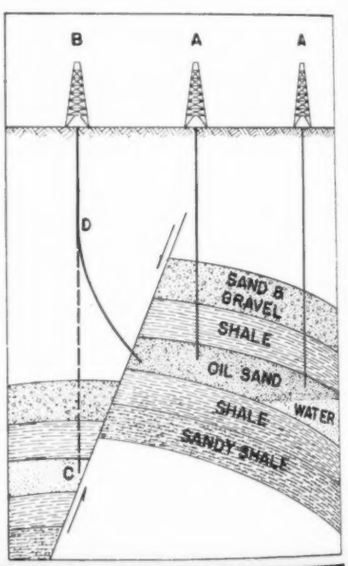

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Directional Drilling and It's Applications to Petroleum Prospecting

CONTROLLED directional drilling in modern petroleum prospecting plays a role that is becoming increasingly important. Surface obstacles such as a body of water, a swamp, rugged topography, or some artificial feature frequently will prevent drilling a vertical hole and necessitate choosing a drilling site at the surface that is some distance horizontally from the desired point to be reached underground. Subsurface obstacles that interfere with drilling a vertical hole are principally formations difficult to drill such as hard cap rock, salt, or heaving shale. Any one or combination of these obstacles may be overcome economically by controlled directional drilling. Another application of directional drilling is in the prospecting of a deep stratum or zone at several points whereby a group of holes may be deflected from one or more main prospect holes.

The three essentials in controlled directional drilling are:

(1) Deflection tools.

(2) Means to orient the deflection tool in the required direction.

(3) Means to survey accurately the path of the hole.

Directional Drilling and Surveying by Lewis-Anderson Methods[1]

The procedure in deflecting a hole with the Lewis knuckle joint and using the Anderson survey instruments is as follows:

When the measurement of inclination and direction has been made, the knuckle joint is oriented into the well so as to set on bottom with the bit pointed in the new direction to be taken by the hole. It is a frequent practice to enlarge the hole for about 30 ft. with a bottom-hole wall scraper before running the knuckle joint. In the case of small holes or when drilling off a cement plug, this permits the use of a larger and stronger tool and gives large hole efficiency in a small hole; moreover, the size of the hole thus can be governed to obtain the desired degree of inclination by the knuckle joint. As shown in Fig. 1 a small hole makes the inclination of the deflected hole small; larger holes increase the angle of deflection.

With the knuckle joint set on bottom and properly oriented, rotation is begun. Constructed to drill at an angle to the axis of the drill pipe, the tool has a drilling assembly that is connected to and rotated by the drill pipe through the medium of a universal joint, as shown on Fig. 2. The drilling assembly is maintained at an angle to and in a fixed direction to the drill pipe by means of a spring-actuated cam in the form of a sleeve with a beveled upper end. The ball and socket permits the direction to be maintained while drilling is in progress.

As drilling continues and the ball and socket joint enter the small hole, the knuckle straightens up and the drill pipe takes care of the necessary curvature for continuing the hole in the new direction. When a deflected hole is carefully drilled its curvatures are moderate. This facilitates the running of casing, for a properly deflected hole usually will take a string of pipe more easily than a vertical hole that has sharp, short bends.

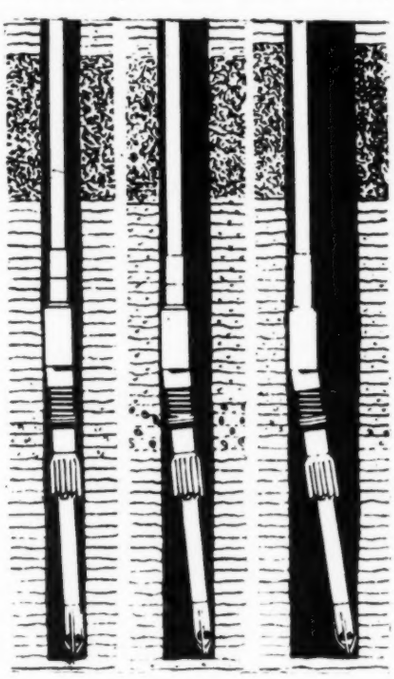

Fig. 1. Showing how size of hole governs the angle of inclination of the deflecting tool

Drilling with the knuckle joint is continued for about 20 feet. This provides ample room for making the survey reading, taken when the tool is pulled out of the hole. After the reading is obtained, a follow-up bit is run on a double of limber drill pipe to make another 20 ft. and when this bit is pulled out the hole is again checked for inclination and direction. It is then enlarged with a pilot-reamer bit, after which drilling is continued in the regular manner in the new direction.

Local conditions and skill of the personnel will govern the number of knuckle-joint deflections made in drilling a hole to a point at a distance from the derrick location. In the coast fields of California where several holes frequently are drilled from one pier location, the average number of deflections per hole now used is from four to five. The man supervising directional drilling is an important factor in obtaining close control with the least number of deflections and most of the companies doing directional drilling on tidewater leases place an experienced man in charge of the work. With proper attention, the number of knuckle-joint runs necessary can be reduced and the hole directed to its objective largely by control of the weight carried on the bit, by using the proper kinds of bits, by governing rotating speed, and by surveying at frequent intervals. This is illustrated by the procedure followed in drilling a well that has just been completed on a tidewater lease.

The rig for this well is on a pier about 800 ft. from shore. It would not have been feasible to get nearer the sand location, as the water gets very deep and the cost of extending the pier probably would have exceeded $20,000. The well was to be drilled to bottom at a vertical depth of 2750 ft. and at a point 500 ft. from the derrick and on a designated line 100 ft. across. The center point of this line was made the objective and the actual completion was within ten ft. of it as shown on the plan of the well, Fig. 3. This meant that an average drift of about 13 deg., or 21.7 ft. per 100 ft., was necessary from a depth of 500 ft., where deflection was started to bottom.

Directional drilling necessitates the use of both inclination and direction measurements and the application of

[1]By Wallace A. Sawdon, Los Angeles, California.

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The method employed is original and entirely different from those previously used. The superiority of Sperry-Sun's Core Orientation lies, not only in its *accuracy* but also in the fact that it *does not interfere with the progress of drilling.* The orientation is determined in a laboratory, to which selected cores, taken by any type core barrels in the ordinary course of drilling and properly marked, are shipped from any distance. *No special equipment* is required at the well, there is no *loss of drilling time.* The resulting saving in time when translated into dollars shows a substantial saving over former methods.

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The samples must be *not less than two (2) inches in diameter and three (3) inches long, perpendicular to the axis.* Samples of larger sizes are preferable.

Samples must be marked "Top" and "Bottom". This is important otherwise the direction of the bedding plane might be reversed by 180°.

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d. If during test polarization or stratification fails to show and customers submit within two weeks another set of samples *from the same well* and if determination of the orientation of this second set is successful, the fee for this second test will be $150.00 minus the amount paid for the first test.

This charge is limited only to the second of two successive determinations.

If core samples are called for at customer's location at his request, a transportation charge of ten cents (10c) per mile will be charged for the round trip.

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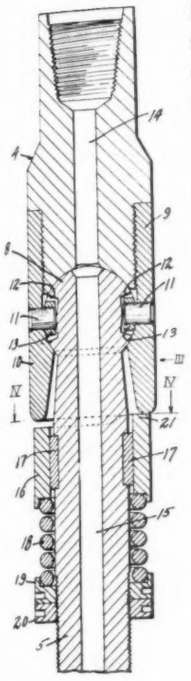


Fig. 2. Cross-section showing construction of the universal joint in the Lewis knuckle-joint

these measurements in directing the tools in their underground course.

An important factor in exploratory work is the obtaining of accurate geological data. Lack of proper underground surveying may make the information misleading. Unless the exact course of a hole is followed, production may be overlooked.

Among the pioneer instruments for measuring direction and inclination at any point during drilling in open hole is the Anderson photo-record magnetic single-shot survey instrument. It does this by providing photographic records of a compass and plumb bob on metal-rimmed discs that are read direct for both inclination and direction. The instrument is run into the hole on sand line and the discs are developed and fixed on the derrick floor so that the reading is available for use within a few minutes after the instrument comes out of the hole.

A small form of this instrument is also used with wire line coring equipment so that measurements of direction and inclination may be made at any depth without the loss of time caused by pulling the tools out of the hole. This small instrument is only one in. in diameter and is run in a durable case whose O. D. is only 1¼ inches.

Between points of deflection during direction drilling the hole must be kept in the direction in which it is begun or made to curve toward a desired direction. Readings with the single-shot survey instruments therefore are made at necessary intervals. Before each deflection, the measurements of both direction and inclination are taken and from the data provided by these the deflecting tool is oriented into the hole.

Drift recorders or go-devils are also used to measure duration during drilling. When a drift indicator is dropped into the drill pipe as a go-devil it lands on a catcher or baffle placed in a sub. When readings of inclination are desired at any time before the tools have to be pulled out, however, it may be run on a wire line.

One such type of drift recorder, the Anderson photo-record go-devil, provides a photographic record on a metal-rimmed disc that is developed and fixed on the derrick floor within a few minutes after the instrument comes out of the well. This record gives an image of plumb bob cross-hairs photographed on the disc, which is preprinted with degree circles. The inclination is read directly from the position of the plumb bob cross-hairs with relation to the degree circles.

Developments in Directional Drilling and Surveying by Eastman Methods[2]

The growing perfection of technique in directional drilling is revealed in the increasingly difficult problems that are being successfully met.

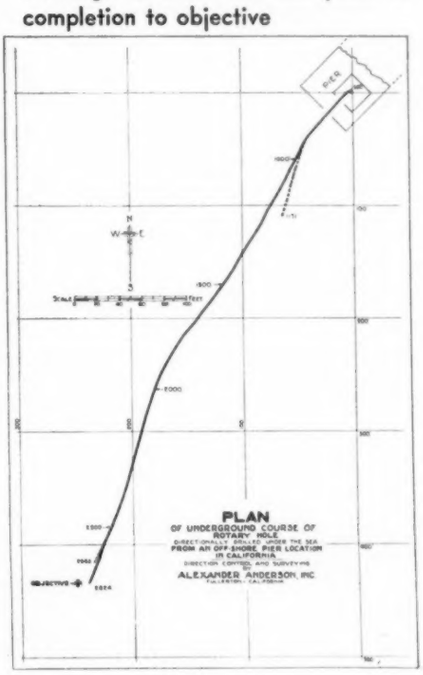
Of the numerous unfavorable factors confronting directional drilling, the most unfavorable often prevails at the very outset, that being the soft plug. Because of its failure to set up harder than the surrounding formation, or hard enough to support the deflecting tool, a soft plug is a great economic waste. A solution to this most common difficulty is being met by means of a mechanical hole bridger and section pre-cast cement plugs that can be set in a hole and deflecting operations begun immediately without any shutdown time. The latest type is illustrated in Fig. 4. The built-in whipstock face makes it possible to drill off with a full-gauge bit, and after sidetracking ten or more feet the bit is withdrawn and a conventional removable whipstock set facing the same way. Drilling by the removable whipstock, the bit is sufficiently displaced in firm formation to insure successful sidetracking. Combining the bridger and plug into an integral unit will mark a great advancement in directional-drilling practice.

Of particular interest is the development of a new type universal joint. When assembled the geared rings mesh and transmit the torque evenly and smoothly regardless of the driving angle. The universal is employed as a deflecting tool by the addition of a 31-in. lower member to the bottom of which is made up a special double diamond point bit.

Orientation of this tool is obtained by hydraulic reaction. One circulating hole is cut in the bit. In operation the tool is oriented to bottom, the lower member hanging straight in the hole, so that the one circulating hole is facing 180 deg., or opposite to the desired direction. With the tool a few feet off bottom the pumps are opened just enough to wash cuttings off bottom, then opened wide. The hydraulic reaction of the fluid jetting from the one hole throws the bit and lower member over to the wall of the hole in the desired line of direction. The pipe is lowered to secure the bit in formation and rotated slowly with from two to four points of weight, depending on conditions. During drilling the rate of circulation is adjusted to the particular conditions of the job.

A number of improvements recently have been developed in oil well surveying practice. The inside single-shot instrument, for instance, adapted to be used in conjunction with retractable wire line coring equipment, now makes it possible to continue the single-shot surveying of a drilling well at regular intervals without the lost time and expense of repeated round trips. This development has proved of particular benefit in deep drilling where the importance of proper knowledge of the position of the hole must be weighed

Fig. 3. Plan of directional-drilled hole showing nearness of actual point of completion to objective



[2]By Jas. D. Hughes, Eastman Oil Well Survey Company, Dallas, Texas.

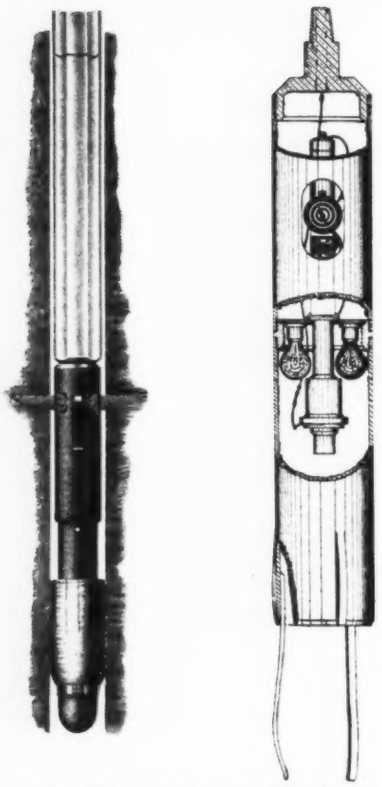


Fig. 4 (left). Mechanical hole bridger with precast cement plugs set in hole for deflecting operations

Fig. 5 (right). Cross-section of camera designed for photographing fish in cased hole

against the cost of obtaining such information. The additional abuse to which an instrument of this type is subjected in falling through a string of drill pipe was responsible for the development of a new full-floating and cushioned clock mechanism that can be sealed independently from the rest of the instrument. A new type of survey barrel footpiece also developed out of these rigorous requirements.

Sufficiently within the scope of oil well surveying to warrant its mention, is the subsurface camera designed and put into service recently for use on stubborn fishing jobs inside casing. Fig. 5 shows it in cross-section.

Another interesting development is the orienting core barrel by means of which a core may be brought to the surface simultaneously with a single-shot directional survey record in such a manner that the original position of the core in the earth may be duplicated and the corrected dip and strike read easily and accurately from the laminations of the core with the assistance of an ingenious reading apparatus. The construction of the device consists of a specially rigged single-shot instrument, a non-magnetic inner barrel to accommodate the instrument, an outer non-magnetic case fitted with a special circulating sub, and the core punch carried on the circulating sub.

The heart of the device is the single-shot instrument, which is constructed with an inside marker extending over the compass card and in alignment with the key secured to the exterior case. By means of this key the position of the inside marker is transferred throughout the assembly until the centering screws finally lock the barrel in place with the core-marking screw in the punch in alignment with the inside marker; thus after the core is punched and marked the relationship between the mark and magnetic north is obtained from the single-shot record.

The information thus gained can be of great usefulness in geological studies, particularly in wildcat operations, salt dome flank drilling, and in cross-faulted areas. Requiring only one round trip of the drill pipe, the device is adapted to modern drilling standards of speed and performance.

Bore Hole Surveying with Gyroscopic Instruments and Directional Clinographs[3]

Among the instruments most widely used for surveying holes in petroleum prospecting is the automatic self-checking, gyroscopic device. The distinctive feature of this instrument is that it employs a gyroscopic directional indicator for recording the true north-south direction, and therefore is not affected by magnetic influences underground, or by casing or tools lost in the hole.

Another property of the gyroscope, the precession, is made use of in compensating the gyroscope for the earth rotation. The gyro pointer is oriented to a true north point and balanced so that it will remain true north during the survey.

An accurate clock and a thermometer are attached to the face of the gyroscopic case. A surface clock, identical and synchronous with the instrument clock, is used for recording the time at certain depth intervals, thereby correlating each exposure with the depth at which it was taken. The inclination is recorded either by a spherical box level gauge, or by a pendulum inclination unit. Between the gyro and the box level gauge is arranged an unique movie film camera, with two lens barrels pointing in opposite directions, one towards the face of the gyro, the other towards the box level gauge. This camera is operated by an electric motor and controlled by a timing device, which also controls the illumination necessary to take the pictures at desired depth intervals.

The camera uses 50 ft. of 16-mm. film and has a capacity of about 1000 records. It superimposes one picture upon the other so that a combined record of inclination and direction is obtained. These records are made while lowering the instrument into the hole and also while bringing it out of the hole, hence duplicate records at all depths are obtained, providing a check. When the instrument is returned to the surface, the film is developed and the records, enlarged by a projector, are interpreted and a map of the hole is drawn.

Various types of directional single-shot Clinographs have been developed for surveying in directional-drilled holes. The majority of them use a magnetic needle or a compass for directional information and a plumb bob for inclinational information. The records are made photographically on sensitized paper.

The instrument as well as the protective casing are made of non-magnetic materials. It is used in open holes only, being lowered on a sand or bailing line at speeds ranging from 400-800 ft. per minute. It is allowed to rest for about four minutes at the depth at which the record is to be taken, after which it is pulled out of the hole. The record is available within five minutes after the instrument has come out of the hole.

The record obtained gives degrees of inclination off the vertical, also the magnetic north. Angles as small as one quarter degree can be easily and accurately measured within one degree on any inclination unit.

Instruments are available in two sizes with an outside diameter of the protective casings of $3\frac{1}{2}$-in. and $1\frac{11}{16}$-in., respectively. The smaller size instrument can be used advantageously in connection with the wire-line type core barrel.

After removing the core barrel and raising the drill stem about 15 to 20 ft., the instrument is lowered through the drill collar to the bottom of the hole and a record is obtained, without making it necessary to pull the drill stem completely out of the hole.

The course and deviation of the hole in controlled directional drilling are checked frequently and the records obtained from the surveying instrument more or less control and direct every move.

[3]Information by courtesy of G. L. Kothny, Sperry-Sun Well Surveying Company, Philadelphia, Pa.

Electrical Logging and Its Applications in Modern Petroleum Prospecting

ELECTRICAL logging, another application of geophysics to petroleum prospecting, has come into wide use in recent years for procuring physical data on the strata penetrated by the drill.

By means of electrical logs the entire section of formations penetrated may be identified. An electric log, even in wildcat wells, usually will disclose valuable information on porosity and saturation, and thus will aid in making a quantitative estimate of the fluid content of the strata.

The Schlumberger Process

Of the few electrical-logging methods in more or less general use, one of the best known is the Schlumberger Process, the pioneer in electrical logging methods.

Resistivity and Porosity Surveys. This process consists of measuring the electrical properties of formations penetrated by a drill hole. The coefficients measured are the resistivity and what is ordinarily called the electrical porosity.

In making a survey the measuring device is lowered into the hole on a cable that contains insulated conductors. A current of constant intensity is sent through the ground, and the measuring electrodes are brought to the potential of the adjacent formation by immersion in the mud filling the hole. This difference of potential is recorded and the log thus obtained constitutes a continuous record of the resistivity of all the strata encountered in that part of the hole under examination.

The aspect known as the electrical porosity of a formation is due to the spontaneous currents generated in a drill hole. These spontaneous currents are the result either of the filtration of the mud filling the hole into the formation, or of the contact of the water filling the hole with the fluid contained in the formation. The currents thus generated obviously are most intense opposite the pervious layers; therefore, the porosity log shows peaks opposite the sands and flat curves opposite the impervious beds.

Both the resistivity and electrical porosity diagrams are recorded simultaneously. The diagrams being obtained directly at the well, the interpretation of the results can be made immediately after the survey.

The principal applications of these surveys in petroleum prospecting are:

(1) Sub-surface correlation between holes.

(2) Detailed study of the formations and location of oil sands passed through in the course of drilling.

Correlations. Electrical logs investigate electically every foot of hole drilled and give a recognizable electrical pattern of every formation encountered. They provide a complete, precise, and economical method of correlation.

The detailed correlations obtained by these logs have thrown a new light on the following problems:

(a) Short Distance Correlations
1. Exact contouring of structure at a number of levels.
2. Accurate detection of faulting, and how it affects the production zone. The pattern of faulting on salt domes, for instance, has been made plain. Unconformities, grabens, tilted blocks and other complications have been located.
3. Study of sands the lensing of which is complex. Where oil accumulations are due to lensing out of sands updip, or to changes of porosity, complicated or not complicated by uplift, electrical logs aid in tracing out these changes.

(b) Long Distance Correlations
1. Regional correlations.
2. Study of regional changes.
3. Comparison of stratigraphy and paleontology.
4. Geological study, and exploration of large territories by very shallow drilling.

Studies of the Formations. The question of whether a sand—or other porous medium—contains oil or gas on the one hand, or salt water on the other, usually can be solved by comparing the porosity and resistivity diagrams of the sands in question. Fig. 1 shows a theoretical electrical log, with its interpretation.

Evaluation of the sand section frequently can be improved by a close study of the electrical log. If there is only one solid sand of uniform character, the log will show it. If there are layers of different character, shaley sections, impervious sands, etc., they will all appear on the log and the

Fig. 1. Schlumberger Theoretical Log, and its interpretation

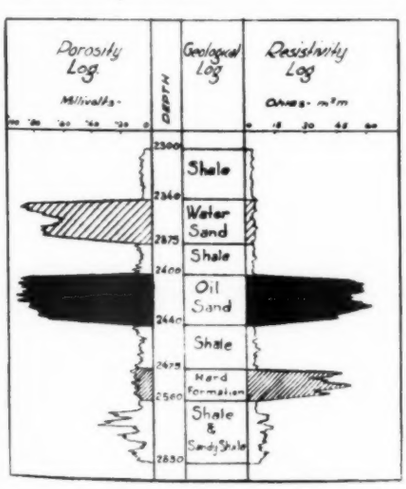
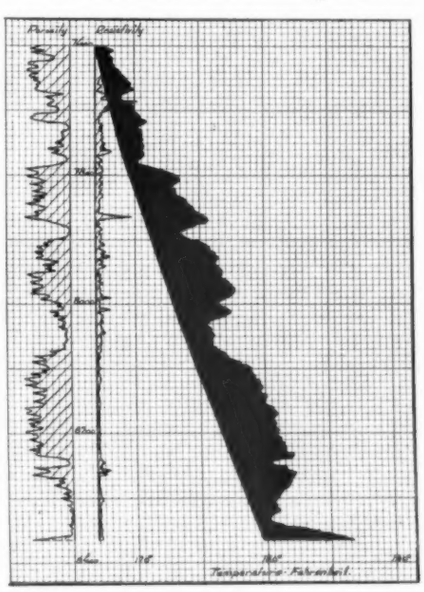
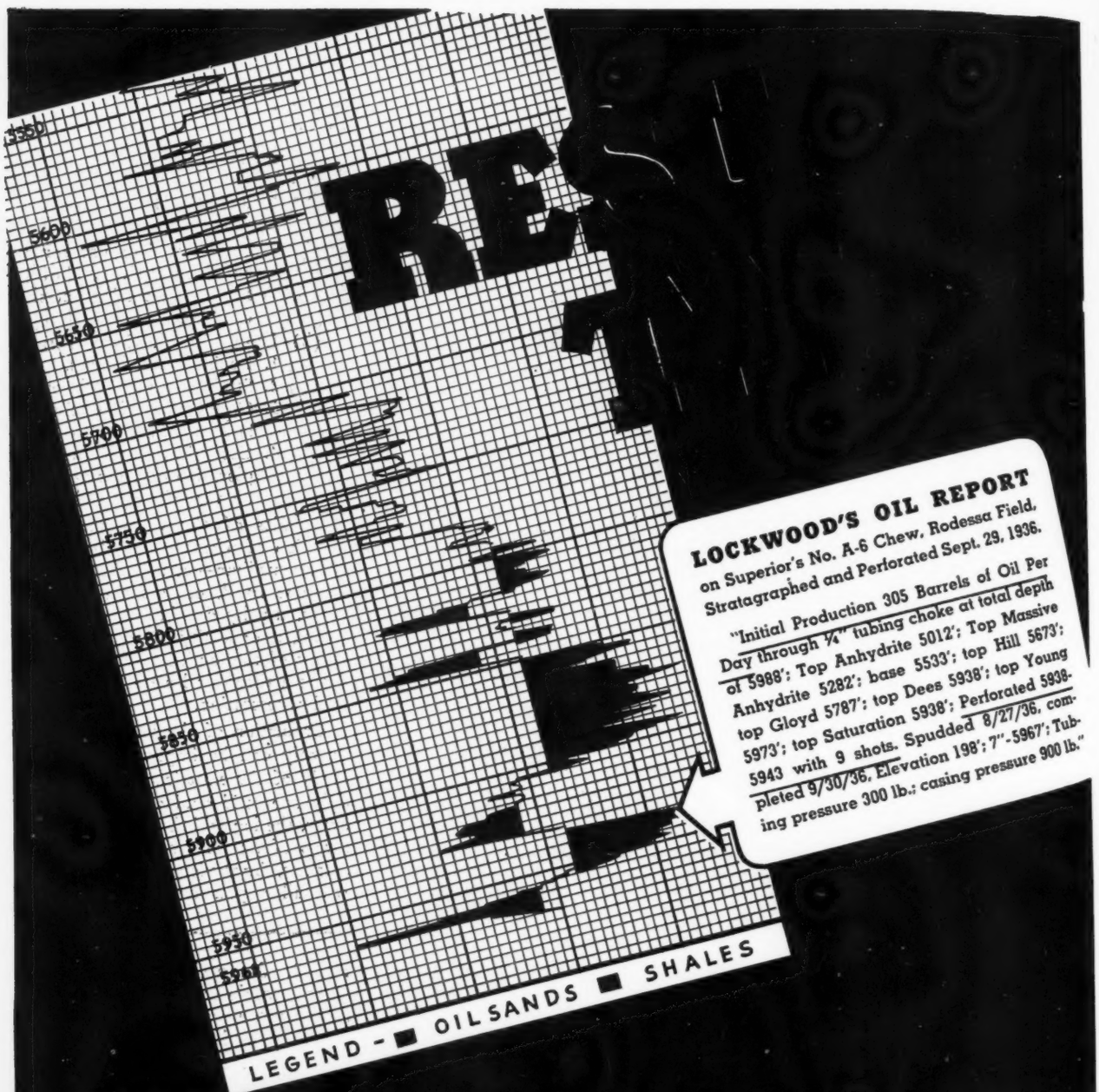


Fig. 2. Schlumberger temperature survey, made in cased hole at Lake Peigneur, La., compared with regular resistivity and porosity curves that were recorded before casing was set

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on Superior's No. A-6 Chew, Rodessa Field,
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amount of net sand section can be ascertained for calculation of reserves.

In limestone fields, the porous zones of a producing section also can be located.

The information afforded by a complete well log is of paramount importance in setting casing, screen, liners, packers, tubing, bottom plugs, etc.

In determining where to perforate casing under the plan of setting casing to bottom and perforating for production, these logs will show not only where the sands are, but where the best parts of them are.

Operating Conditions. The diameter of the standard electrodes and weights used in the Schlumberger process is 3⅜ inches. When the mud filling the hole to be surveyed is very thick, it sometimes is necessary to use auxiliary weights of larger diameter.

If for some reason (bridge, cave, etc.) it is impossible to reach the bottom of the hole, the electrodes may be run inside of the drill pipe (with weights of 2⅞ to 1⅝ inches, O.D.) down to the point that it was impossible to pass in the first part of the survey, thus completing the entire log of the hole.

Temperature Surveys

This is also another phase of the Schlumberger process. Measurements of temperature in drill holes have been made for many years, but ordinarily to determine the temperature gradient of the formations. It is only recently that such measurements have been recorded continuously from the surface with convenient apparatus. Methods have been developed and suitable instruments designed for this purpose.

An electrical thermometer spliced to the normal cable is lowered into the hole and readings are taken from the surface. A variation of one-fifth of a degree fahr. may be easily recorded.

Recent work proves that temperature surveys can be advantageously used for:

1. Locating gas-oil bearing strata in open hole.
2. Locating the water-bearing formations discharging fluid into a well.
3. Locating the top of the cement behind the casing.
4. Logging the different formations behind the casing.

Locating Gas-Oil Bearing Formations. A temperature survey will locate accurately a gas-oil-bearing formation. The gas bubbling out from the formation during the drilling, or produced if a test is made, will cool off the formation at the point where it enters the hole, the cooling effect being due to the expansion of the gas.

Using the electrical thermometer, the cool point will be easily located, and the depth of the gas-producing formation disclosed. For example, the temperature survey made in a well producing oil, water, and some gas showed plainly a colder zone around 6500 feet, which was interpreted as a gas-bearing formation. This interpretation was found to be correct when the well produced nineteen million cubic feet of gas with distillate and no water, after being plugged back to 6680 feet.

Such surveys are made with fluid, preferably mud or water, filling the hole.

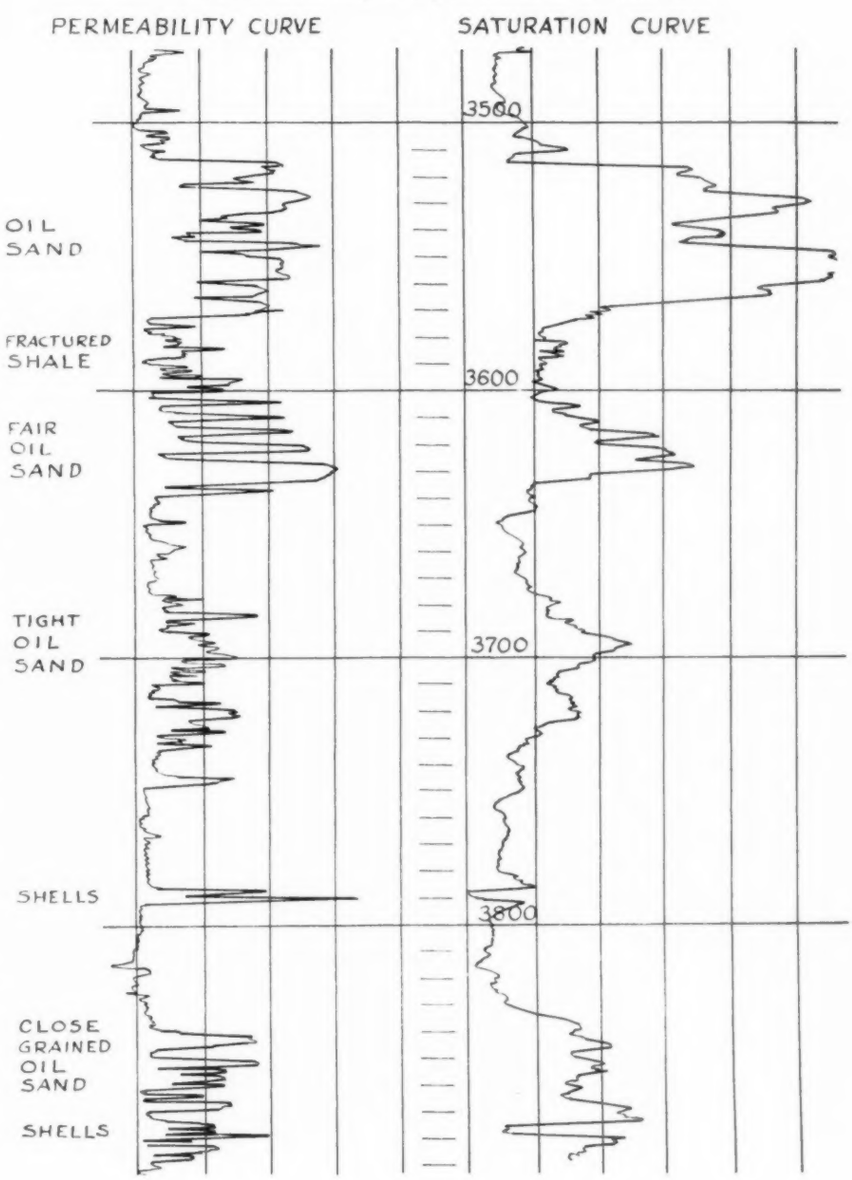
The temperature curve is taken a few hours after terminating circulation.

The best results are obtained if the survey is made immediately after or during the time the gas is bubbling out in the mud, in order to take full advantage of the maximum cooling effect.

Locating Top of Cement. In many cases it is of great value to know the exact level reached by cement behind the casing when it is set, either for future perforating jobs, for eventually pulling out the casing, for cementing of shallow gas sands, or for cementing of salt water sands, thus preventing pollution of the fresh water. A temperature survey will give the needed information. For example, in one well surveyed the heat generated by the hardening cement had raised the temperature of the mud below 3200 feet. This point indicated the level of the cement.

The best time to make the survey is

Fig. 3. Geoanalyzer log of a well in California



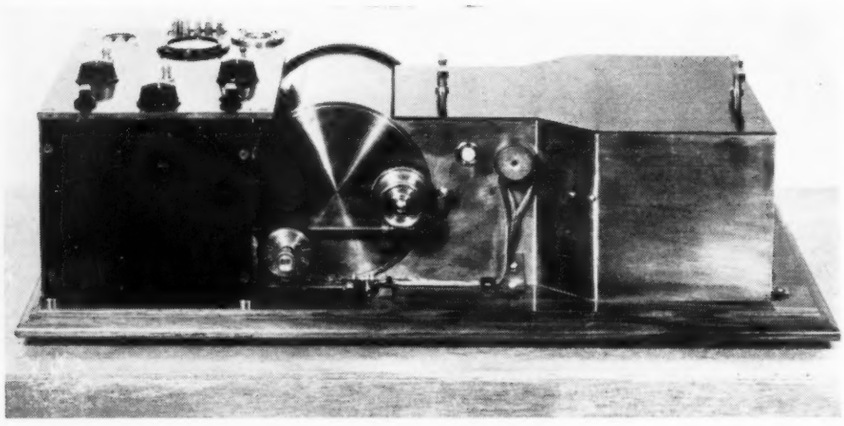


Fig. 4. The recording instrument used in the Geonalyzer method of electrical logging. Its entire operation is automatic and the film is ready for use within a few minutes after the logging operation has been completed

as soon as possible after placing the cement. Drilling mud should not be circulated before the survey is made.

The time required for the survey is only a few hours, the recording speed being approximately 1200 feet an hour.

The top of the cement can be determined immediately at the rig, and all necessary information given before the crew leaves the well.

Logging Formations Behind the Casing. Due to the difference in heat conductivity between the formations, temperature logs recorded in open and even in cased hole show accurately the top and base of the various sands and shales traversed by the well.

Fig. 2 is an example of a temperature survey made in a cased hole compared with the regular resistivity and porosity curves that were recorded before the casing was set. The sands and interbedded shale are easily recognized, the sand beds being several degrees warmer than the shale.

Any time after the hole is cased, the temperature survey can be made to log formations behind the casing. Some fluid, if possible, mud or water, must fill the section to be surveyed. The fluid must be thoroughly circulated before beginning the survey, and its temperature must be different from that of the formation in the section to be surveyed. Two or more temperature runs are made if necessary, until the result is obtained. In order to make a correct interpretation of a temperature diagram in a cased hole, it is desirable to have, for comparison, a well in the same neighborhood, electrically logged before the casing was set, and run with a temperature diagram a certain time after setting the casing.

The Geoanalyzer Method

Another well-known method of electrical logging is the Geoanalyzer method. This method of electrical logging provides two curves from which interpretations are made and subsurface data procured. These curves are photographed on a strip of film six inches in width, which is developed and fixed ready for use within a few minutes after the logging run is completed. The entire operation with this method is automatic and, when confidential records are desired, the developed film can be removed from the developing tank and turned over to the oil company without being seen even by the operator of the electrical-logging equipment.

The subsurface instrument contains two electrodes, each of which is connected to the surface equipment by a conductor. The conductors are enclosed in an armored cable on which the instrument is run into the well. The surface equipment is housed in two trucks or a truck and trailer with one truck containing a hoist by means of which the instrument is lowered and raised in the well. The other truck or trailer contains the recording equipment and complete facilities for developing the film.

Electric current from the surface is conducted through one conductor to the electrode in the instrument. The electrode is slightly lower than the other electrode and any convenient ground is used for this circuit. No current is passed down the conductor to the upper electrode. As the instrument is raised in the hole, an electro-magnetic field is impressed on the formation surrounding the hole in the immediate proximity of the instrument and measurements of the electrical reaction on the successive strata and their contained fluid are made.

Referring to Fig. 3, showing the two curves made, the left graph is a measurement of resistivity and is called the permeability curve. It is based on shallow electrical penetration and and from it the formation data (such as sands, shales, fractured zones, shells, etc.) can be determined. Low values on the curve indicate shales or bodies with a low percentage of voids. High values indicate formations with a greater percentage of voids. Here also can be determined a change in mineral content, the highest values being obtained in non-aqueous or very tight formations.

The graph on the right (Fig. 4) is called the saturation curve and is based on deeper electrical penetration. It indicates the voltage drop through the formation opposite the instrument at the time the reading is taken. From this curve basis for deduction on the fluid content of the formation can be made and it is used as a means of indicating oil, salt water, fresh water, etc. High values usually indicate oil or fresh water; low values, salt water. This curve is particularly adaptable to interpretation in conjunction with the permeability curve after the productive zone is reached. Low values will mean salt water even though mechanical cores show satisfactory oil saturation.

In areas where the naturally-occurring water may be of low salt content it has been found that by employing alternating current a saturation curve can be procured that will give a more secure interpretation; also, by using alternating current of a suitable frequency, external electrical disturbances (such as from car lines) can be entirely obviated.

Due to the unique electrode arrangement in the geoanalyzer instrument, the circuits are able to delineate small details and pick up thin bodies in logging the formations. Fig. 3 shows the lower portion of a log of a well in California and portrays this feature. As will be noted, the oil sands have high values on both curves and the values on the permeability curve are less in the tight sands than in the more porous zones. The two breaks of shells are quite evident with their high permeability and low saturation values. Below the lower shells indicated is also a small stratum of tight oil-bearing sand in which the well was stopped.

The recording equipment is an automatic photographic device utilizing an oscillograph. This is shown in Fig. 4. The film is unrolled in synchronism with the movement of the subsurface instrument as the latter is raised in the hole. Exposed upon the film during operations are two moving beams of light, which are actuated by the changing electrical reactions that

are conducted to the recording instrument from the electrodes in the well through the armored cable on which the subsurface instrument is run. The camera arrangement is motor-driven and the depth is recorded by another light that flashes at each 10-ft. interval. In most instances, the curves are synchronized to scale at 50 ft. per inch but can be adjusted to scale at 100 ft. per inch or, when desired for closer definition, at 20 ft. per inch.

The range of speed at which the instrument is moved up the hole is from 100 to 150 ft. a minute. The automatic recording provides for rapid logging and is thus frequently of advantage in cases where the operation must be done rapidly. For example, in a certain well where 2500 ft. of hole was to be logged electrically from a depth of 7300 ft. up to 4800 ft., the well was gassy and it was necessary to go back into the hole every 40 or 50 minutes to prevent it from blowing out. The total elapsed time for this operation, including the running to bottom and pulling out from the 4800-ft. depth after the logging had been completed, was 45 minutes.

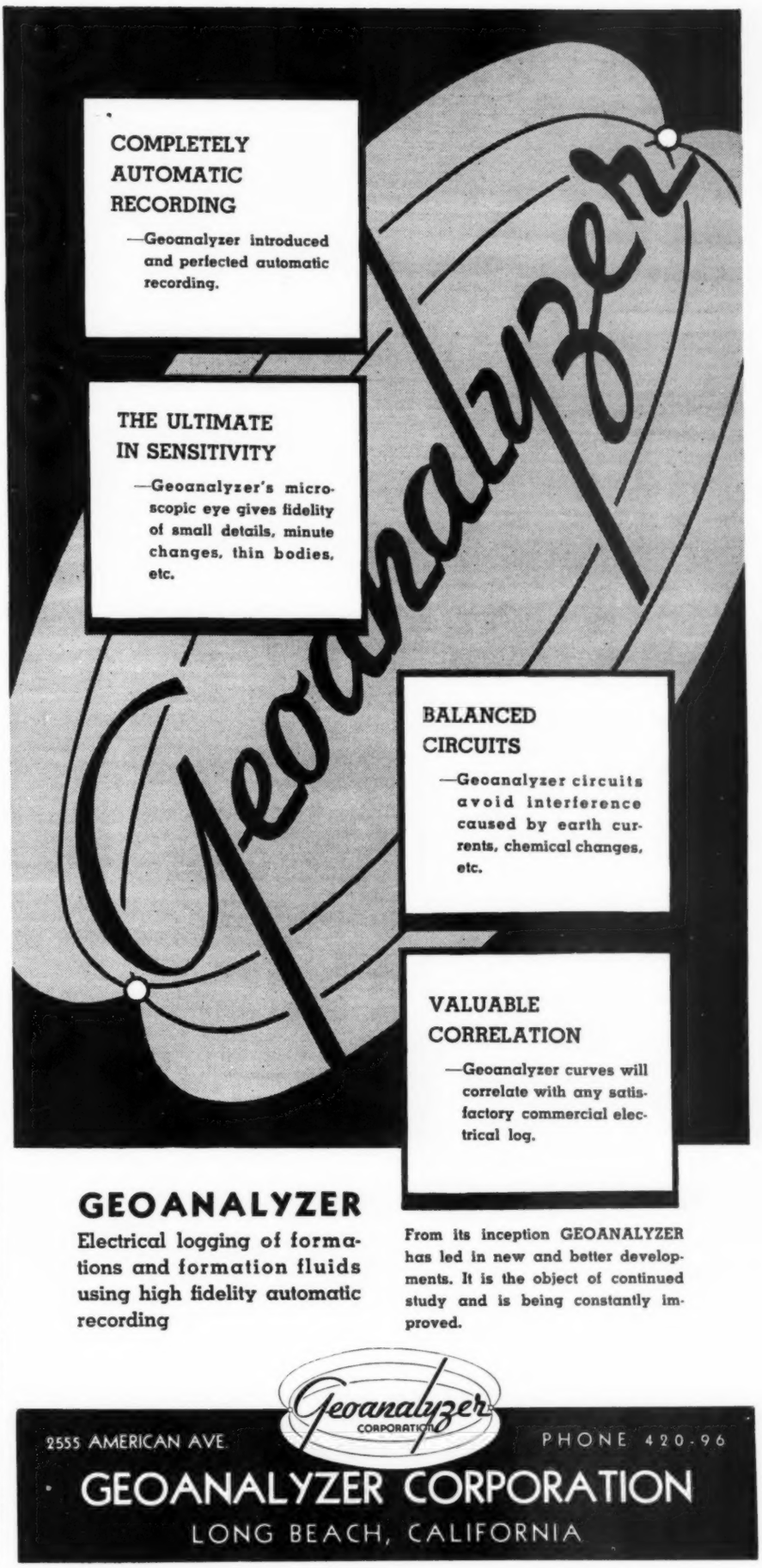
The Stratagraph Method

Still another method of obtaining an electrical log of a hole is the Stratagraph method. Available information on the application of this method is too meager to discuss it at any length. One of the distinctive features claimed for the method, however, is its ability to record electrically at the surface the electrochemical characteristics of the strata lying behind the casing in the hole; in other words, an electrical log of a cased hole can be made by this method. By using certain electrolytes in the well, records are obtained by running electrodes into the liquids in the casing.

In petroleum prospecting it is used for correlating in fields where little is known of the substructure.

The method has another application in providing information on subsurface conditions in a producing oilfield, especially in regard to structural and water conditions; and to determine the character of formations at specified depths. The contamination by encroaching water, the connate-water and oil content of sands and shales electrochemically distinguish the different layers that are used as definite markers to be identified from well to well for correlation purposes.

By using certain electrolytes in the well and lowering electrodes into the casing on a conductor, a record is obtained at the surface of the electrochemical characteristics of the formations behind the casing.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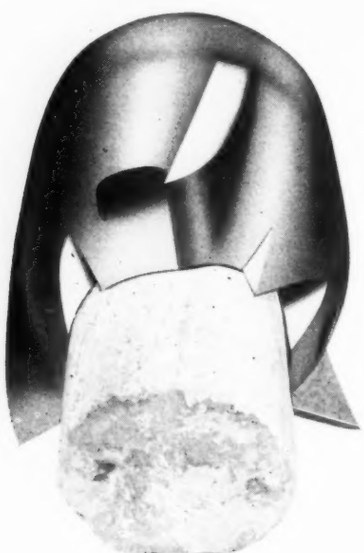

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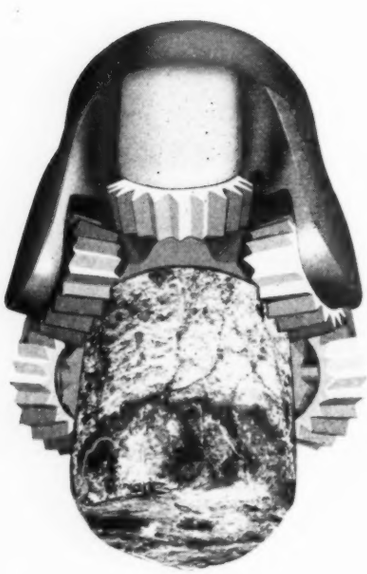

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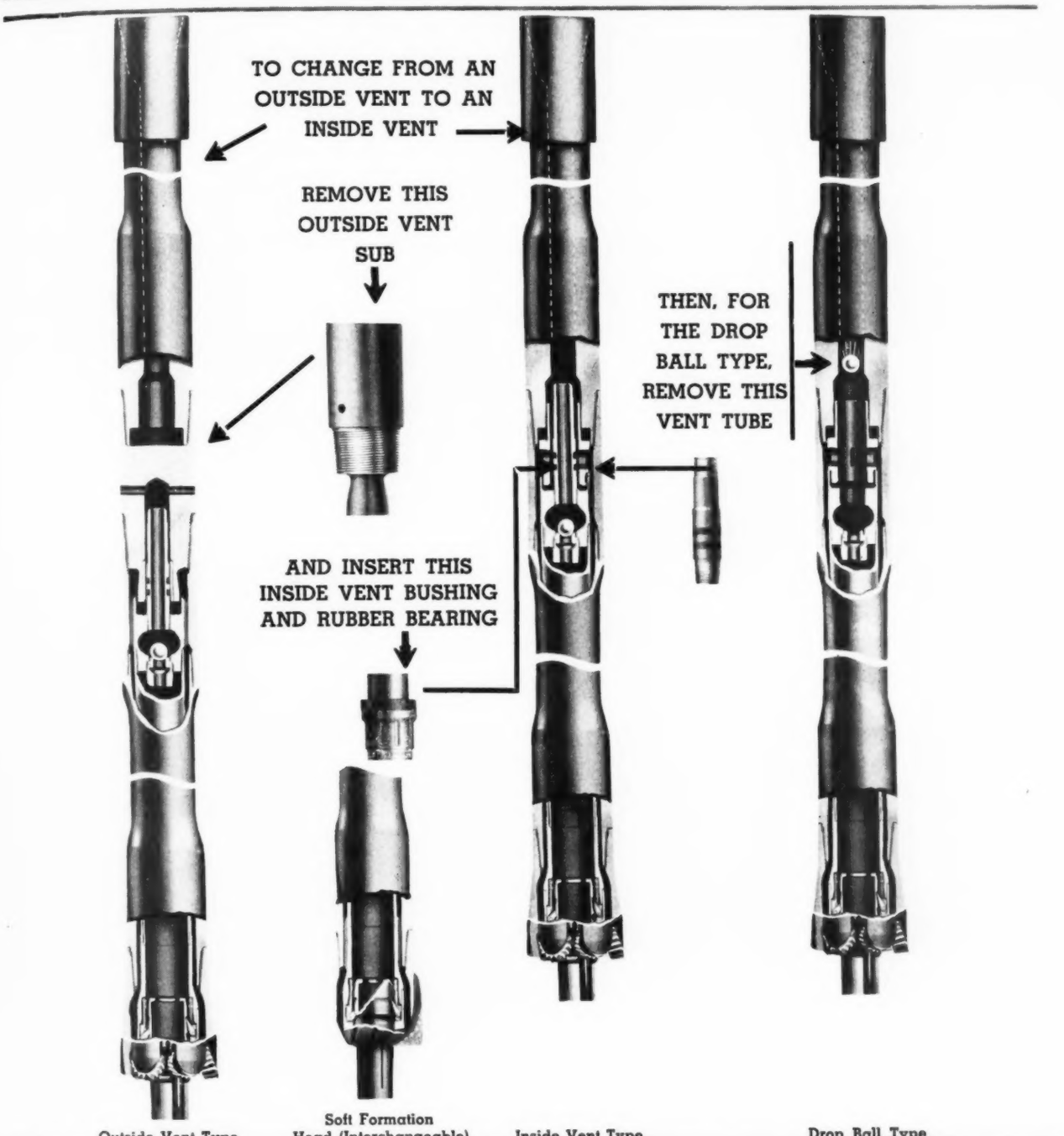
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AND INSERT THIS INSIDE VENT BUSHING AND RUBBER BEARING
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Coring and Its Applications in Modern Petroleum Prospecting

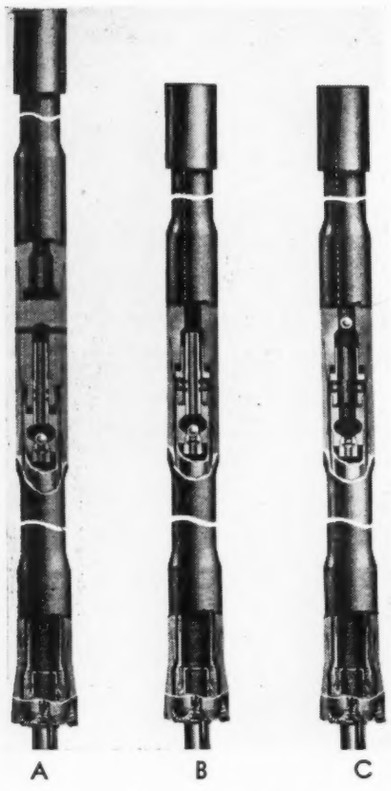

Fig. 1. Means of venting fluid (A) Outside vent type; (B) Inside vent type; (C) Drop ball type

SINCE the introduction of the double-barrel core drill 15 years ago, coring has been one of the chief aids in petroleum prospecting.

Cores may be examined for water-bearing sands in strata too thin to register on the recording instruments of electrical prospecting devices, or sands bearing fresh water and hence indistinguishable from oil sands in their electrical conductivity.

Quite accurate methods have been developed for determining the porosity and permeability of reservoir rocks from cores.

Coring programs for wildcat wells vary with the territory and largely are the result of a compromise between the necessity of cores and the cost of coring. Common programs are: one core every 100 ft., one every 50 ft., ten ft. of core and 15 ft. of uncored hole, two ft. of core and eight ft. of uncored hole.

Modern Coring Methods[1]

There are two distinct methods of coring in use today. Removing the drill stem from the hole, replacing the drilling bit with a coring bit, returning to bottom with the core drill, cutting the core, removing the drill stem from the hole and returning to bottom with a drilling bit to ream the core hole is the conventional method used in those cases where only a few cores are necessary to establish markers for the entire hole. This method would apply in proven territory or in any area where sub-surface control has been established. The other method commonly known as the wire line method of coring, is used mostly in wildcat and semi-wildcat work, where it is important for present and possible future needs to obtain all available information. With this method the core barrel is removable from the bottom of the hole on a wire line. The bit is a combination drilling and coring bit either of scrape type or rock bit design, provided with a central hole through which the removable core barrel is allowed to protrude. If a core is desired, the kelly is removed, the core barrel picked up on the derrick floor and allowed to float to bottom inside the drill stem. The kelly is then replaced, coring accomplished in the usual manner, and when the core has been cut the kelly is again removed. A small overshot operating on a wire line is then introduced inside the drill pipe and, upon reaching bottom, grips the removable core barrel and brings it to the surface on its upward trip.

All core barrels consist of three main parts: the outer barrel, the inner barrel, and the core cutter head with catcher.

The outer barrel is merely an envelope that screws on to the drill stem and in the lower end of which the cutter head is screwed. The circulation downward is between the outer and inner barrels.

The inner barrel receives the core and contains in its upper extremity the valve or vent.

Two outstanding improvements in conventional core barrels in recent years are the introduction of the non-rotating or floating type of inner barrel and the design of the finger type core catcher.

The inner barrel formerly was allowed to rotate with the outer barrel and drill stem, thus turning around the core, creating much unnecessary friction and tending to damage the core as it moved up the barrel. The present trend is to make both the inner barrel and core catcher non-rotating. If a core catcher is made to rotate around the core, the protruding fingers or wedges of the core catcher continually tend to tear up the core. Likewise, a good hard rock core will tend to tear up the core catcher so that it might become ineffective when it comes time for the core catcher to bite off and hold the core. With core catcher and inner barrel non-rotating, the outer barrel and cutter head rotate around to cut away the formation to form the core, then the core catcher and the inner barrel simply slip straight down slowly over the core to give it full protection.

The design and position of the core catcher are important factors that the manufacturer can control. The catcher should be as near to the bottom of the hole as is practical, thus permitting core recovery very close to the bottom of the hole.

Another factor in good core recovery is the design of the means of expulsion of fluid from within the inner barrel as the core is being formed and progresses upward. This expulsion of fluid is accomplished by a valve or

Fig. 2. Hard formation cutter head with roller cutter bits

[1]By John Klep, Reed Roller Bit Company, Houston, Texas.

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Rodessa Exchange	Phone 256		Phone C-6811	Phone 781

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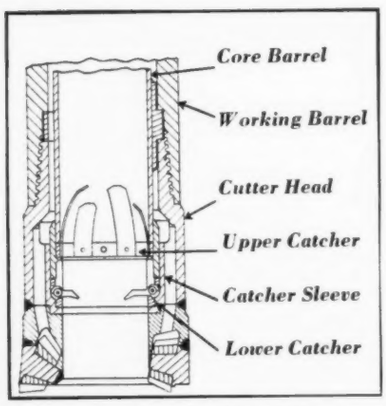


Fig. 3. Section showing spring-actuated dog type catcher

vent situated at the top extremity of the inner barrel. There are three different ways of effecting fluid expulsion: the outside vent, the inside vent, and the inside vent with the drop ball valve (see Fig. 1). The outside vent operates to lower the pressure on top of the core by providing an outlet for the mud above the core through the vent to the outside of the drill stem; thus the core entering the inner barrel is assisted by pump pressure from below rather than resisted by pump pressure above the core from within the drill stem. The inside vent consists simply of a ball and seat at the top of the inner barrel. Should it be desired to flush the inner barrel after it has been put on bottom for any particular length of time, the drop ball type of valve should prove more satisfactory.

The Wire Line System of Coring in Wildcat and Semi-Wildcat Holes. In wildcat operations, and in general wherever much coring is to be done, whether it be in soft or hard formations, the use of the wire line core barrel is becoming increasingly general. When deep drilling became a reality it was discovered that coring with conventional tools was an extremely costly operation because of the time lost in making round trips and reaming core holes. The wire line core barrel has removed these drawbacks.

Rotary Core Drilling[2]

Improvement of the modern core bit has been a great aid to the widespread use of the rotary method of drilling wells.

Present Types of Core Bits. Double-tube core barrels are the type in general use today. The overshot drill collar, vent sub, and working barrel make up the structural connection between the drill stem and cutter head, while the inner barrel or core barrel only serves to protect the core from the flushing fluid and is free to swivel with the core. The core catcher assembly consists of an upper catcher with spring fingers and a lower catcher with spring-actuated, pivoted dogs, held in correct position in the bit by a hardened adapter sleeve. The same assembly is used in both the hard and soft formation cutter heads, and is placed as close to bottom as possible.

The inner barrel is vented to the outside of the drill stem through the strainer cap, ball seat, stuffing box, and vent spider passage. This arrangement allows free entrance of the core independent of pump pressure, by allowing fluid entrapped above the core to exhaust into a low-pressure area.

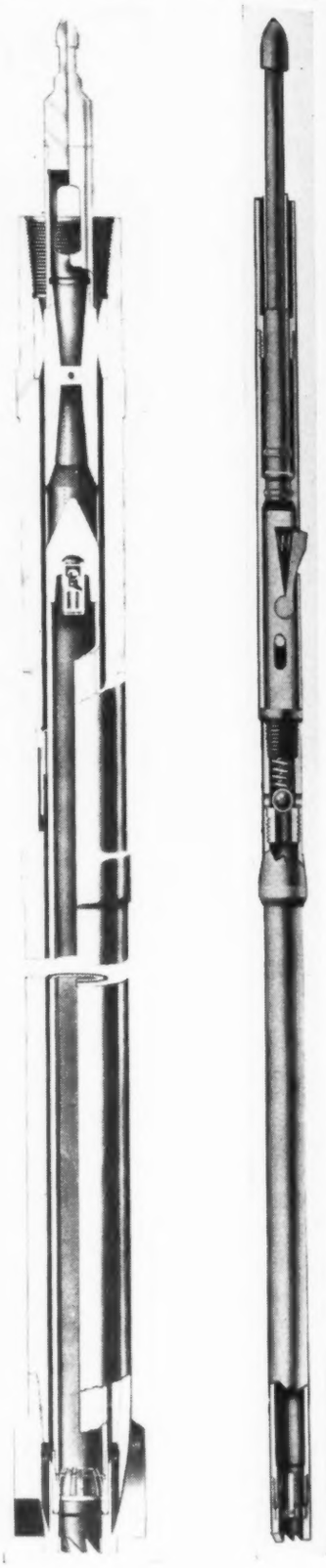
Cutter heads are of two general types, drag or blade type for soft formations and roller type for hard formations. Soft formation cutter heads are essentially drag bits with hard-faced blades adapted to cut a core of the proper size. Flushing fluid is guided close to the cutting edges to cool the blades and clear the hole of cuttings. Multi-bladed bits are used in larger sizes for smoother operation, and are suitable for smaller cutter heads where formations are firm and not inclined to ball up.

Hard formation cutter heads are mostly roller cutter bits, varying only in the arrangement and number of cutters, cutter mounting means, and cutter shapes. Cutters are held in place by welding hardened bearing shafts to the cutter head; water holes are drilled to jet each cutter for washing and cooling. In general, six cutters, arranged as shown in Fig. 2, have been found to offer the best balance between rough drilling bits and less rugged cutter heads with numerous cutters.

An important part of a core barrel is the core catcher. The oldest of the three popular core catchers is the spring type where spring fingers bear against the core and start a bridge to hold the core when bit is lifted. This type has its most valuable application in very soft, unconsolidated formations. The second type of popular core catcher is the spring-actuated dog type shown in cross-section in Fig. 3. This design has greater strength and is adaptable to a wider range of formations. A third catcher is a combination of the second type with the spring-operated dogs, and a series of slips adapted to wedge in a tapered bowl around the core when the bit is lifted. The slips tighten when the core resists movement and the core is broken off at the slips or below them. There are many other types of core catchers on the market utilizing mechanical means to operate the core retaining means.

There are several designs of retractable core bits or core bits with which

Fig. 4. (Left) Elliott core barrel
Fig. 5. (Right) Brewster core barrel



[2]By L. E. Garfield, Hughes Tool Company, Houston, Texas.

from below 10,000 feet
AT OLD OCEAN, TEXAS

Again in the Old Ocean area, Brazoria County, Texas, on Harrison & Abercrombie's No. 3 Bernard River Land & Development Company, a 3-inch Cameron Type "C" Rotary Core Barrel is delivering the facts to the derrick floor. Notwithstanding that considerable hard sand and shale has been encountered, the 3-inch Cameron Core Barrel has cut and recovered between 85% and 90% of all formations cored from 10,036 to 10,307, total depth at this writing.

Above is illustrated the first core cut after 7-inch casing was set at 10,004 feet. Twelve feet of formation was cut between 10,036 and 10,048 feet, and twelve feet of core was recovered as indicated. Replacement of a damaged lower core catcher resulted in full gauge cores being recovered on subsequent runs.

Even in the small 3-inch size, you can absolutely depend on a properly maintained Cameron Type "C" Core Barrel to produce maximum recovery of full and uncontaminated core from any depth.

CAMERON IRON WORKS, INC.
711 MILBY STREET HOUSTON, TEXAS
Export Office: 74 Trinity Place, New York, N. Y.
Midland: W. P. (RED) KNIGHT
Louisiana: PELICAN WELL TOOL & SUPPLY CO.
Oklahoma and Kansas:
CARSON MACHINE & SUPPLY CO.

Fig. 7. (Above) Bottom of Dean core barrel

Fig. 6. (Left) Cameron Iron Works core barrel

the inner barrel and core can be retrieved at intervals through the drill stem. Round trips are necessary only when the bit becomes dull.

These bits are divided into three general classes. The first two are provided with a wire line for retrieving the inner barrel. One of these has the core barrel seat in the cutter head and the main cutter head forms the core. The inner tube is locked in place under a sub and is free to swivel with the core. The other has a core head on the inner barrel that provides a new shoe each time for forming the core. This type is locked against rotation and protrudes two to six inches ahead of the main bit. The extended position is maintained by spring pressure so that the shoe may back up into the main bit head when hard strata are encountered.

The third type has the inner barrel seat in the head like the first type, the main difference being that the inner barrel is held down on its seat by pump pressure. If the inner barrel becomes full or fouled so that no more core can enter, the inner barrel lifts, restricts the fluid area, and thus raises the pump pressure. The inner barrel can then be pumped out by reversing returns or may be "fished" with a wire line. When the reversed circulation method is used to retrieve the inner barrel assembly, it is made longer than the longest length of pipe in the string, so that the inner barrel assembly acts like a piston in at least one tool joint bore.

Bits and Core Recovery. Core size or diameter cut in a given size hole is very important for good recovery in the more difficult formations. The ratio of the area of the core to the area of the hole has a bearing on the amount of core recovered, all other things being equal. If the ratio is large, the core recovery is better and vice versa. This may be attributed to several factors:

(1) The area of cut being large will cause more vibration to be transmitted to the bit and to the core, and result in disintegration of brittle or friable formation.

(2) Large kerf or area cut makes progress slower, giving the core more time to break up and wash away.

(3) Weight needed to make efficient progress with a core head cutting a small core and a large kerf is sometimes excessive, thus causing the core to shatter.

(4) Inherent strength of the core, assuming solid formation, is proportional to the section modulus or proportional to the cube of the diameter. Thus a larger core is much stronger.

(5) Large cores in porous formations are necessary for best recovery because the core must be larger than the largest cavity to have any structural material to form a core.

Various Types of Rotary Coring Bits

Fig. 4 shows a core drill whose cutter head has four outside cutters and two inside.

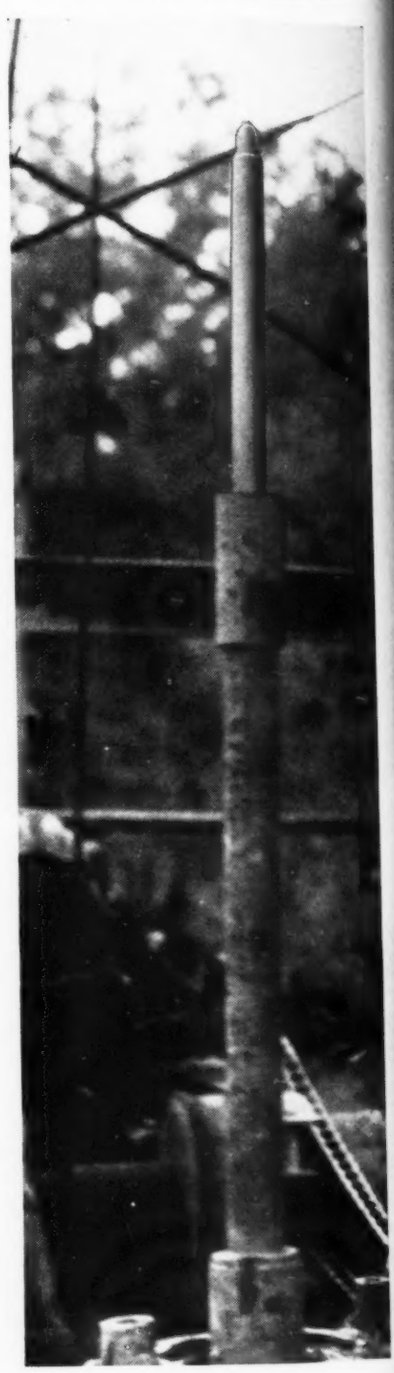
In Fig. 5 is shown an inner core barrel of the type that is run on a wire line.

A rotary core barrel that has an idling or non-rotating inner barrel, core lubrication, multi-diameter inner barrel assembly, and a unique core catcher assembly is shown in Fig. 6.

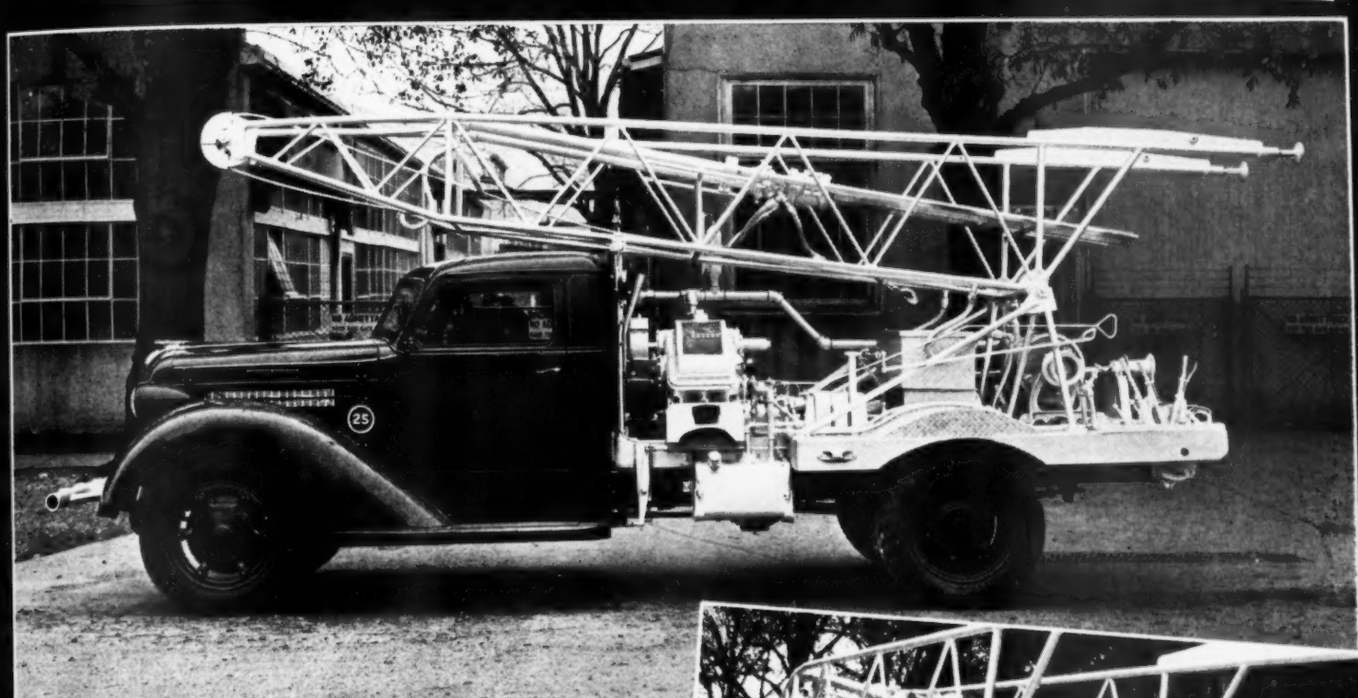
The type of core drill illustrated in Fig. 7 has a roller-bearing rock-type core head with o.d. roller reamer cutters. The core catcher is closed by mud pump pressure, and cuts all cores off at bottom.

The signaling-type core barrel (Fig. 8) embodies an arrangement whereby, by means of a rise in circulating pressure as registered on a pressure gauge on the slush pump discharge manifold, the driller is signaled when the core tube is in correct position to receive the core, and again when the core tube is filled. This core barrel may be pumped by hydraulic pressure down inside the drill pipe, and pumped back to the surface when the core is taken.

Fig. 8. Pennington signaling core barrel just pumped out of drill stem



W-K-M SHOT HOLE and CORE DRILLING RIGS *for* EXPLORATION WORK



● Ready to go on location at full truck speed.

Here's the last word in Shot Hole and Core Drilling . . . embodying advantages previously unavailable to exploration departments. Drills 0 to 500 feet. The unit consists of a rotary table, hydraulic Kelly feed, circulating slush pump, power driven hoisting drum, and folding mast . . . . . utilizing full power of the truck motor through a heavy-duty split-shaft take-off. The patented long-stroke hydraulic Kelly feed eliminates several chucking operations, thereby materially cutting down drilling time.

Descriptive folder upon request.

Other Portable Drilling Rigs for depths to 6000 feet.

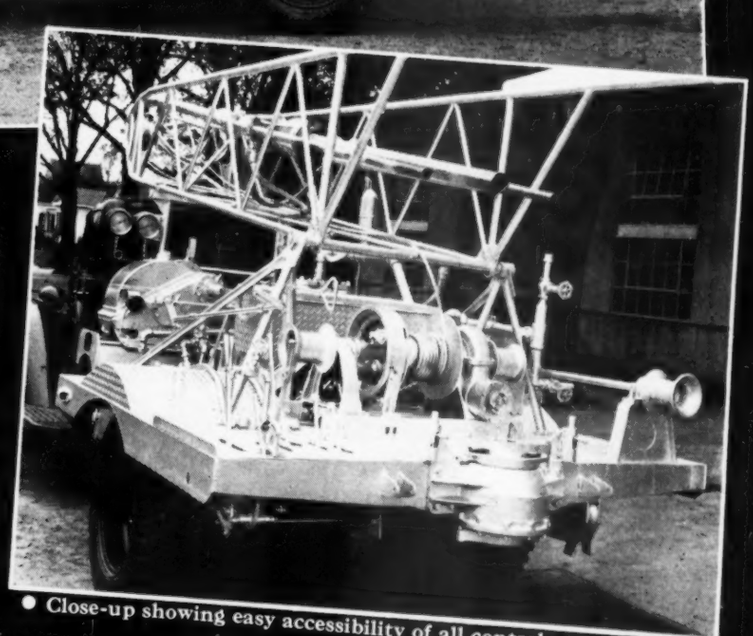
W-K-M Company, Inc.

OIL FIELD . PIPE-LINE & INDUSTRIAL EQUIPMENT

HOUSTON, Texas, U. S. A.

Export Office: 74 Trinity Place, New York

Cable Address: "WILKOMAC"



● Close-up showing easy accessibility of all controls to the driller.

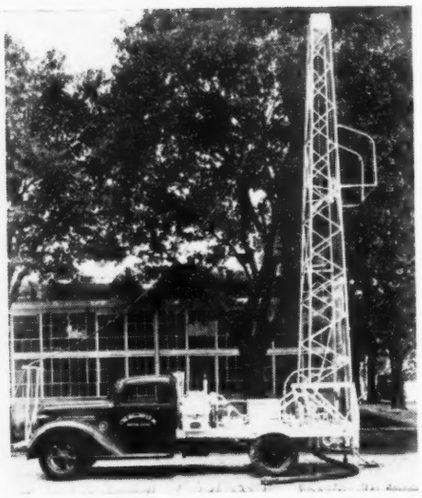


Fig. 9. Modern portable drilling rig

Portable Coring Rigs

Portable drilling units used in taking cores are manufactured by several companies. One such modern unit is shown in Fig. 9. These units are mounted on a light truck chassis and thus are able to traverse country often inaccessible to heavier equipment. Most of the units receive their power from the truck's own power plant.

Formation Testers

It has become common practice to test with formation testers the productivity of formations that show oil or gas as they are penetrated without the necessity of first setting a string of casing. Briefly the method consists of lowering through the drilling fluid a test string equipped with a packer and a valve inlet, the latter being at the lower end of the string. The equipment is so designed that fluid from the well is excluded. The packer is set above the formation and the valve opened to admit entrance of connate fluid from the formation.

Cable Tool Coring[3]

The old method of relying on cuttings to provide subsurface information when drilling with cable tools has been superseded almost entirely by the method of coring with the cable tool core barrel.

A cable tool core barrel is shown in Fig. 10. In operation of the Baker core barrel shown, the inner tube section, which takes and retains the core, is not raised from bottom once it has set down. It has no motion except to follow down over the undisturbed sample of the formation as the outer barrel cuts an annular hole around the core. The outer barrel functions as any cable tool. A feature of this core barrel is a ball check valve that permits any water that may be trapped in the core tube to escape as the tube fills with the core. This prevents fluid under pressure from acting on the core.

Cable tool cores are recovered in various lengths, their size depending on the hardness of the formation. When the stratum is extremely hard the cores will be in the form of biscuits. With softer formations, where the jar caused by drilling will not fracture the sample, the cores often will be a foot or more in length. The complete core made during a run, however, will give a sample of the formation as it actually lies in the ground, as there is no contamination after the tool begins to core.

Core analyses on wildcat wells frequently are made in the field. For permeability and porosity tests, the sample should be from 1½ to 4 in. in length; for a saturation test, a 1-in. sample is sufficient.

Under average conditions, the coring speed is about ten percent slower than normal drilling speed, and there are many formations encountered in which the coring bit will cut as fast as the drilling bit. Cable tool coring is not affected by high hydrostatic head; also, if a productive sand is struck, coring can be continued in the presence of large flows of oil and gas without injury to the core and with a recovery as high as under ordinary conditions.

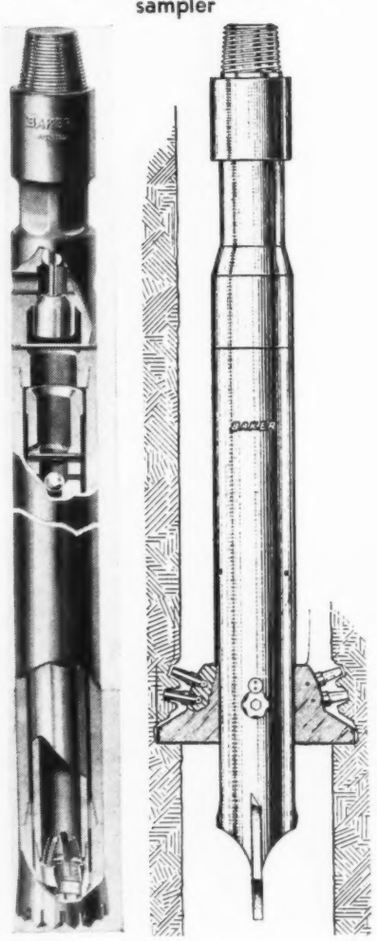
Wall Sampling Devices

Cores are sometimes lost or sections of a hole may be drilled without coring at points where later it is decided that samples should be taken. It may be necessary to have check samples in certain strata to verify other core data. When the hole is being drilled with rotary tools, samples of the formation may be taken at any desired point before that point in the hole is cased off. Such sampling is done by means of side-wall sampling devices. Two such devices in use are here discussed.

One of these, the Baker hydraulic

(Continued on Page 171)

Fig. 10. (Left) Cable tool core barrel
Fig. 11 (Right) Baker hydraulic wall sampler

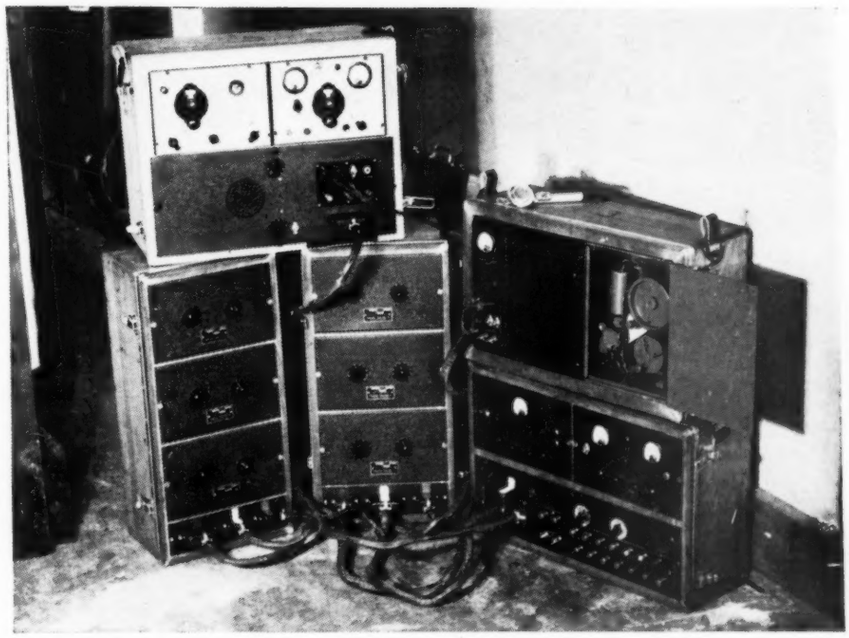


[3]By Wallace A. Sawdon, Los Angeles, Calif.

Fig. 12. Samples obtained with Schlumberger sample taker

SEISMIC EQUIPMENT FOR PORTABLE USE

SEISMOGRAPH Service Corporation, Tulsa, Oklahoma, sent a crew of five men with the equipment shown in the accompanying illustration to Port of Spain, Trinidad, during the month of January, to start a program of exploration there for the Antilles Petroleum Company of Trinidad. This equipment usually is mounted in a truck, but in view of the fact that the work in Trinidad is all portage work, through swamps and over timbered hills, it was especially constructed in units not exceeding 100 lb. each, and mounted in cases completely waterproofed. These instruments are entirely standard, otherwise, and nothing was sacrificed to make them portable. The equipment was designed and manufactured for Seismograph Service Corporation by Engineering Laboratories, Inc., Tulsa, Oklahoma.



(Continued from Page 168)

wall-sampler, Fig. 11, is operated hydraulically by the mud pump pressure. Blades on the sampler are expanded into the wall of the hole. Each blade has two core-taking tubes screwed into its upper edge. After the blades have been expanded at the desired point in the hole circulation is discontinued. The tubes then cut and retain samples from the wall of the hole as the tool is rotated. These samples range in size from 7/16 in. to 11/16 in. in diameter and from 1¼ in. to 2½ in. in length, depending on the size of blade and size of hole.

Another side-wall coring device, brought out recently by Schlumberger, has its main application in the testing of oil or gas sands that the electrical log has indicated as favorable for production.

Small empty core barrels, or cartridges, are shot into the face of the sand to be tested. The device is mounted in groups of several cartridges in a metal container and is screwed to the base of the electrode container used in electrically logging the hole. Should a sand look favorable it may be cored immediately by lowering an electrical detonating device to that point in the hole opposite the face of the sand from which the core is desired.

The powder charge used is governed by the hardness of the formation to be penetrated. One cartridge is discharged at a time; thus, several separate zones can be tested at one loading.

The empty cartridge cuts into the wall of the hole for its core and remains attached to the container by an uncoiled spring. The filled cartridge with its tell-tale evidence is hoisted out of the hole with the cartridge container. (Samples taken with the device are shown in Fig. 12.)

At the surface each sample is transferred to a cylindrical glass sample tube, which is labelled with all the necessary information regarding the source of the sample.

Ask the Man Who Runs One

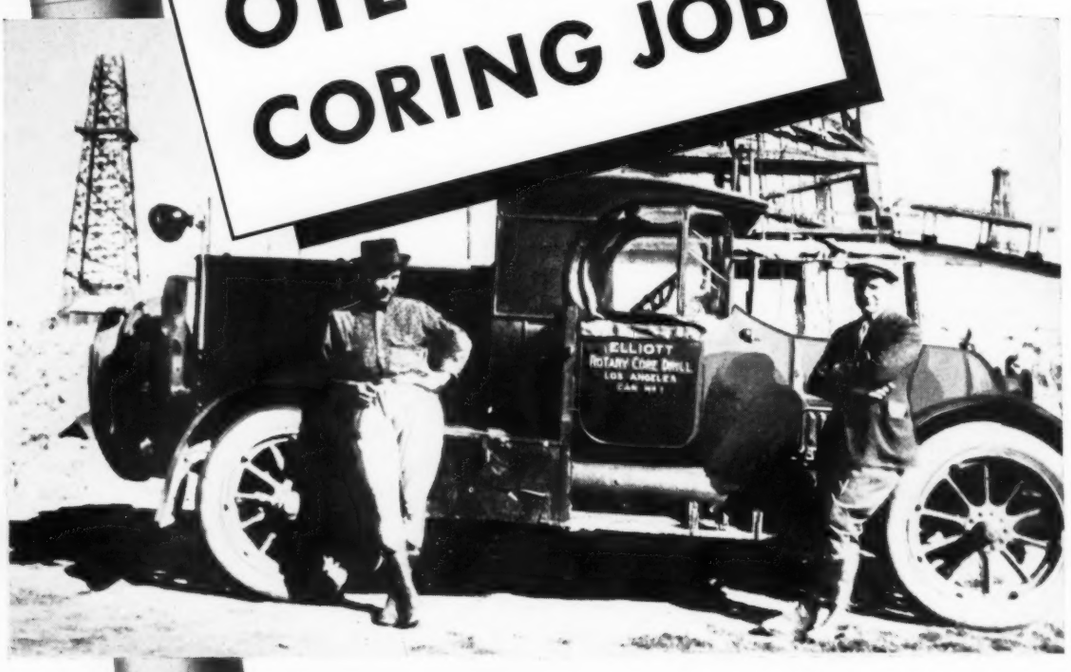
Ask drillers who are using Dean Core Drills about their performance. A smile like the one Driller Lorenz Wahl is wearing in the picture above will tell as much as the invariable words of praise.

As in coring this wildcat well—Butler No. 1 at Puente, California—Dean Core Drills give uniformly gratifying performance, recovering clean-cut specimens from the softest or hardest formation, whatever the depth.

DEAN
OIL TOOLS

DEAN OIL TOOL COMPANY
3200 Alameda Blvd. Route No. 2, Box 3200
COMPTON, CALIFORNIA

The FIRST OIL WELL CORING JOB



An Elliott Field Service Truck and crew (1922). J. E. "Brick" Elliott, right, and Floyd Glass.

THE PIONEER and the LEADER

OIL WELL coring service on a commercially successful basis dates back to 1921. In July of that year Elliott cored the first well (National Exploration Co's. "Newland-Borchard No. 1" at Huntington Beach, California), using equipment designed, developed and manufactured exclusively by this company. That this first coring job was eminently successful in every sense of the word is a matter of permanent record—an important event in petroleum history.

Previously, coring was merely a stunt — usually just a futile gesture. Oil companies had made frequent attempts to core, but with the crude tools available it was truly a spectacular achievement when just a few inches of burned, churned-up core was recovered.

Elliott has been a pioneer and a leader in the development of coring as a definite part of drilling procedure. Through intensive specialization Elliott has been privileged to blaze the trail, while Elliott equipment has established and maintained the highest standards of performance, in oil well coring practice.

ELLIOTT CORE DRILLING COMPANY
4731 East 52nd Drive, Los Angeles, California, U. S. A.
Export Office: 420 Lexington Avenue, New York, N. Y.

ELLIOTT
RAPID AND CABLE TOOL CORE DRILLS

Many Have Reserved Space for Houston Show

Officials of Oil-World Exposition, Inc., announce that reservations are coming in rapidly from exhibitors for the petroleum show to be held at Houston, Texas, October 11-16. The list of those who already have reserved space is as follows:

A-1 Bit Company, Houston; Abegg & Reinhold Co., Inc., Los Angeles; Abercrombie Pump Company, Houston; Ahlberg Bearing Company, Chicago; All Steel Products Manufacturing Co., Wichita, Kansas; Allen-Sproull & Allen, Houston; American Chain & Cable Company, Bridgeport, Connecticut; American Hammered Piston Ring Co., Baltimore, Maryland; American Iron & Machine Works Co., Oklahoma City; American Manufacturing Company, St. Louis; American Optical Company, Dallas; American Roller Bearing Company, Pittsburgh; American Sand-Banum Co., Inc., New York; Alexander-Anderson, Inc., Fullerton, California; Atlas Engineering Works, Houston; Authorized Appleman Bit Service Co., Inc., Houston; Ayres Engineering Company, Houston; American La France & Foamite Corporation, Elmira, New York.

Baash-Ross Tool Company, Los Angeles; Baker Chemical Company, J. T., Phillipsburg, New Jersey; Baker Oil Tools, Inc., Huntington Park, California; Baldwin-Duckworth Chain Co., Springfield, Massachusetts; Baroid Sales Company, Los Angeles; Becker, Inc., Christian, New York; Benjamin Electric Manufacturing Co., Des Plaines, Illinois; Bethlehem Steel Corporation, Bethlehem, Pennsylvania; Bettis Rubber Company, Los Angeles; Big Three Welding Company, Houston; Black, Sivalls & Bryson, Inc., Oklahoma City; *Brown Instrument Company, Philadelphia; Byron-Jackson Company, Los Angeles; J. E. Bobo, Houston.

Cameron Iron Works, Inc., Houston; Cavins Bailer Service, Long Beach, Calif., Houston; Chain Belt Company, Milwaukee; Coast Oil Fields Specialities Co., Los Angeles; Coen Company, Inc., San Francisco; *Continental Supply Company, Dallas; Coors Porcelain Company, Golden, Colorado; Corning Glass Works, Corning, New York; Crosby Steam Gage & Valve Co., Boston; Crouse-Hinds Company, Syracuse, New York; Crutcher-Rolfs-Cummings, Inc., Houston; Cummins Engine Company, Columbus; Curtin & Company, W. H., Houston.

Dannenbaum Company, M. N., Houston; Darling Valve & Mfg. Company, Williamsport, Pennsylvania; Dean Bros. Company, Indianapolis; Dura metallic Corporation, Kalamazoo, Michigan.

Eastman Oil Well Survey Company, Dallas; Edward Valve & Mfg. Co., Inc., The, East Chicago, Indiana; Erie Tool Works, Erie, Pennsylvania; Everlasting Valve Company, Jersey City.

Failing Supply Company, Geo. H., Enid, Okla., Houston; Fischer Company, C. A., Fort Worth; Fisher Governor Company, Marshalltown, Iowa; Fix Company, Geo. J., Dallas; Flagg & Company, Stanley G., Philadelphia; France Packing Company, Philadelphia; Frick-Reid Supply Corporation, Tulsa.

Gardner Denver Company, Quincy, Illinois; Garlock Packing Company, Palmyra, New York; Garrott Brass & Machine Company, Houston; Gaso Pump & Burner Company, Tulsa; Gas Power, Inc., Houston; Guiberson Corporation, Dallas; Gulf Engineers, Inc., Houston; Gulf Publishing Company, Houston; Goodall Semi Metallic Hose Co., Philadelphia; Halliburton Oil Well Cementing Co., Duncan, Oklahoma; Harnischfeger Corporation, Milwaukee; Hays Corporation, The, Michigan City, Indiana; Hercules Motors Corporation, Canton, Ohio; Hewitt-Gutta Percha Rubber Company, Buffalo; Hills-McCanna Company, Chicago; *Houston Oil Field Material Co., Houston; Hughes Tool Company, Houston; Hyatt Bearings Div.-General Motors Corp., Newark; Houston Slush Pump Repair Co., Houston.

International Equipment Company, Boston; International Nickel Company, Inc., New York.

Jefferson Union Company, Lexington, Massachusetts; Jenkins Bros., Inc., New York; Johns-Manville, New York; *Jones & Laughlin Steel Company, Pittsburgh; Joyce-Cridland Company, Dayton, Ohio.

Kennedy Valve Manufacturing Co., Elmira, New York; Kimble Glass Company, Vineland, New Jersey; Kinzbach Tool Company, Houston; Koppers Construction Company, Pittsburgh; Kunkle Valve Company, Fort Wayne, Indiana.

Lamb Piston Sales Company, Torrance, California; Landis Machine Company, Waynesboro, Pennsylvania; Larkin Packer Company, St. Louis; Layne & Bowler Company, Houston; Leschen & Sons Rope Co., A., St. Louis; Lincoln Electric Company, Cleveland; Link-Belt Company, Chicago; *Lufkin Foundry & Machine Co., Lufkin, Texas; Lunkenheimer Company, The, Cincinnati.

M & H Valve & Fitting Co., Anniston, Alabama; *Maintenance Engineering Corp., Houston; Mair Machinery Co., D. S., Houston; Martin-Decker Corp., Long Beach; Mepham Corp., Geo. S., East St. Louis; Merco Centrifugal Separator Co., Ltd., San Francisco; Merco Nordstrom Valve Co., Pittsburgh; Meriam Company, The, Cleveland; Mid-Continent Supply Company, Fort Worth; Mine Safety Appliances Company, Pittsburgh; Mission Manufacturing Company, Houston.

*National Supply Company, Toledo; *National Tube Company, Pittsburgh; Norvell-Wilder Supply Company, Beaumont.

Oakite Products, Inc., New York; Oil & Gas Journal, Tulsa; Oil Center Tool Company, Inc., Houston; *Oil Well Supply Company, Dallas; O'Leary King Company, Houston; Olympic Engineering Company, Los Angeles; Osage Metal Company, Oklahoma City; Oster Manufacturing Company, Cleveland.

Petroleum Electric Power Club, Houston; P & D Specialty Manufacturing Co., Houston; The Petroleum Engineer, Dallas; Pittsburgh Equitable Meter Co., Pittsburgh; *Portable Rig Company, Houston; Powell Company, Wm., Cincinnati; Precision Scientific Company, Chicago; Production Equipment Company, Beaumont; Pyrene Manufacturing Company, Newark.

Rector Well Equipment Company, Fort Worth; Red Rex Corporation, Houston; Reed Roller Bit Company, Houston; Regan Forge & Engineering Co., Houston; Republic Steel Corporation, Cleveland; *Republic Supply Company, Houston.

Safety Equipment Service Company, Cleveland; Service Pattern & Model Works, Houston; Shaffer Tool Works, Brea, California; Smith Supply Company, Nowery J., Houston; Southern Engine & Pump Company, Houston; Spang, Chalfant & Company, Inc., Pittsburgh, Spencer Lens Company, Buffalo; Sperry-Sun Well Surveying Co., Philadelphia; Strong, Carlisle & Hammond Co., Cleveland.

Tagliabue Manufacturing Co., C. J., Brooklyn; Templeton, Kenly & Company, Ltd., Chicago; Texacone Company, The, Dallas; Texas Electric Steel Casting Co., Houston; Texas Rubber & Specialty Corp., Houston; Texas Steel Company, Fort Worth; Thornhill-Craver Company, Houston; Timken Roller Bearing Co., The, Canton, Ohio; Tobin Aerial Surveys, Edgar, San Antonio; Tretolite Company, Dallas; Turbolite, Inc., Houston; Twin Disc Clutch Company, Racine, Wisconsin; Twin Seat Valve Company, Beaumont.

*United American Bosch Corp., Springfield, Massachusetts; United States Gauge Company, New York; *U. S. Steel, Illinois Carnegie Steel Corporation, Pittsburgh; Universal Engineering Company, Ltd., Los Angeles.

Vernon Tool Company, Ltd., Los Angeles; Victor Welding Equipment Company, San Francisco; Vortox Manufacturing Company, Claremont, California.

W-K-M Company, Inc., Houston; Walworth Company, South Boston, Massachusetts; Western Block Company, Lockport, New York; Western Sand-Banum Company, Inc., Houston; *Wickwire Spencer Steel Company, New York; Williams & Company, J. H., New York; Williams Valve Company, D. T., Cincinnati; Williamsport Wire Rope Company, Williamsport, Pennsylvania; Wilson Supply Company, Houston; Wilson, Webb, Huntington Park, California.

Zink Company, John (Burners), Tulsa.

*Concerns who have reserved space—awaiting contracts.

Plan Big Natural Gas Convention in Kansas City

Plans for the largest convention ever held by the Natural Gas Department of the American Gas Association rapidly are being completed. The meeting will be at Kansas City, Missouri, May 10-14. All meetings and exhibits of gas appliance and equipment manufacturers will be held in Kansas City's new $6,500,000 municipal auditorium.

It will be the first exhibit held at a natural gas convention by the newly organized Association of Gas Appliance and Equipment Manufacturers. It also will be the first exhibit held in connection with a natural gas convention since the annual meeting held in Kansas City in 1929.

The program for both the general sessions and the sectional meetings of the various committees was arranged at a meeting of the program committees recently in St. Louis, Missouri. All subjects to be discussed and the speakers were agreed upon at this meeting.

Those in charge of the convention expect at least 3000 gas men to attend. C. W. Berghorn, executive secretary of the Association of Gas Appliance and Equipment Manufacturers, expects that practically all the 120,000 sq. ft. of available exhibit space will be taken far in advance of the opening.

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

To Err Is Human

Well dressed man, cigar in hand, falling through the air from an airplane: "Gad! That wasn't the wash room after all."

* * *

"The thing for you to do," said the doctor to the man with frazzled nerves, "is to stop thinking about yourself—to bury yourself in your work."

"Gosh!" returned the patient, "and me a concrete mixer."

—*Magnolia News.*

* * *

"Henry, do you still act toward your wife the same as you did before you were married?"

"Just the same. I remember when I first fell in love with her. I would lean over the fence in front of her house and gaze at her shadow on the curtain, afraid to go in. And I act exactly the same way now."

* * *

A colored country preacher, who was strong on visiting the lady members of his congregation, was traveling along the road to the home of one of his flock when he met the small son of a lady member. This conversation ensued:

"Whar's you' maw?"
"She's home."
"Whar's you' paw?"
"He's home."
"Tell 'em 'howdy' fuh me."

* * *

Short Story

Oh, George, let's don't park here.
" " " " "
" " " "
" " "
" "
"

* * *

Two Scotchmen were watching a football game; one had a bottle, the other had only a thirst. The bottle-man was talking very largely about his knowledge of the game and what fine player he was himself.

During the conversation he helped himself very liberally to the contents of his bottle, whereupon the thirsty one said: "Weel, I notice ye're a fine dribbler, but ye're nae guid at passing."

Salesman (beginning to unroll his samples): "I'd like to show you—"

Merchant (emphatically); "No, no. I'm not interested."

Salesman (eagerly): "But couldn't I just show you—"

Merchant (firmly); "Not a chance. I'm not interested."

Salesman (wistfully): "Well, would you mind if I looked at them myself? I haven't had a chance to see them for three weeks.

* * *

A few years ago it was the radio that got poor reception. Now it's the fellow who comes around for the payments.

* * *

A: "The artist I pose for does painting, etching and sculpturing."

B: "But, of course, he does one thing better than anything else."

A: "Yes—but he's pretty good at painting, etching and sculpturing."

* * *

If all the boarders in all the boarding houses were placed side by side at one table, they'd reach.

* * *

First Heel: "What'll it be, you skunk? Swords or pistols?"

Second Ditto: "If I were a skunk, would I need a sword or a pistol?"

* * *

A Scotchman was leaving on a business trip, and he called back as he was leaving: "Goodbye all, and dinna forget to take little Donald's glasses off when he isna lookin' at anything."

—*Ohio Sundial.*

* * *

Mountaineer: "Doc, I want you to look at my son-in-law. I shot at him yesterday and took a piece out of his ear."

Doctor: "Shame on you, shooting at your son-in-law!"

Mountaineer: "Huh! He wasn't my son-in-law when I shot at him."

* * *

Coach: "What's the matter with you fellows, you look like a bunch of amateurs, today."—*N. Y. U. Medley.*

* * *

"Did you keep the date with your girl last night in all that rain?"

"Naw, I waited for her two hours, and she didn't come, so I stood her up."

Wrong Office

A young fellow entered one of those very lavish New York office buildings, as he had an appointment for an interview with a certain advertising firm there.

He got out of the elevator on the twenty-fifth floor, which he had ascertained to be the landing the firm was on. The elevator boy pointed vaguely toward the office the young man had requested.

He entered and was met by a colored chap.

"Are you Mr. Hopkins' secretary," he asked.

"No, suh, boss," the negro replied.

"Is his secretary around?"

"No, suh; not around hyah."

"Well, could I see Mr. Hopkins?"

"He aint' hyah, either."

"Well, I think I'll just sit here and wait for him."

"Why do that, suh? Just go into his office. He doesn't use this lavatory much."

* * *

"I was out with a nurse last night."

"Well, cheer up. Maybe your mother will let you go without one soon."

—*Cornell Widow.*

* * *

He: "Just one kiss, dearest."

She: "No, dear, we haven't time. Father will be home in an hour."

* * *

"You gave me a bum steer," said the milkmaid as she came away with an empty pail.—*Texas Ranger.*

* * *

Then there was the man who could only afford to send his son to college for two years, but who let him go, as he figured that half a loaf was better than none.

* * *

A Stranger Himself

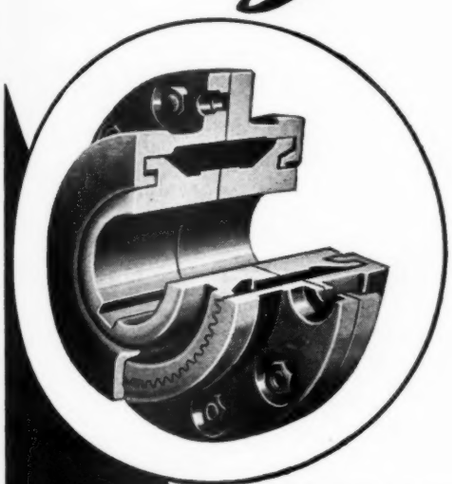
The quack was selling an elixir which he declared would make men live to a great age.

"Look at me," he shouted. "Hale and hearty, and I'm over 300 years old."

"Is he really as old as that?" asked a listener of the youthful assistant.

"I can't say," replied the assistant. "I've only worked for him 100 years!"

"Tough" Jobs



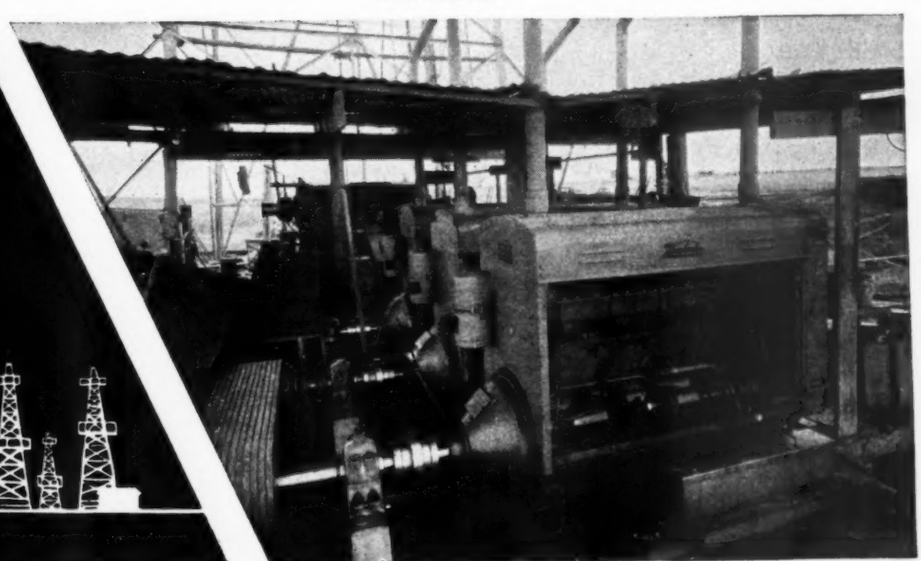
THE illustration above shows Fast's construction. No perishable materials are necessary to make it dust and moisture proof.
FAST'S PATENTS COVER THESE VITAL FEATURES

ENGINEERS in the oil fields are learning that on "tough" applications, such as drilling rigs, geared powers, pumping units, hot-oil pumps, etc., Fast's Self-Aligning Couplings give trouble-free performance during the entire life of the connected machines. *Dependability* is built into them through correct design, good workmanship and reliable materials.

The load-carrying surfaces of a Fast's Coupling are protected against wear by a positive film of oil. This oil is kept permanently clean by the rocking bearings which make precise metal-to-metal contact, forming permanent dust and moisture proof seals. No perishable materials, springs, grids, etc., are required.

You can prevent operating trouble by specifying *genuine* Fast's Self-Aligning Couplings on the machinery you purchase.

KOPPERS COMPANY
BARTLETT HAYWARD DIVISION
BALTIMORE MD.



Fast's Couplings on three Waukesha motors at the Harry Blackstock Drilling Company, Edmond, Oklahoma.

FAST'S COUPLINGS

Running Tour
WITH MEN IN THE INDUSTRY

J. W. VAIDEN, who since 1933 has been superintendent in charge of natural gasoline plants for the Skelly Oil Company of Tulsa, Oklahoma, has been made manager of the natural gas and natural gasoline division of the production division. He has been with the company 12 years.

H. W. KLEIN, Tulsa, Oklahoma, general superintendent of production for the Stanolind Oil and Gas Company, resigned and on February 1st moved to Dallas, Texas, associating himself with **GRADY H. VAUGHN.** They have formed the Big West Drilling Company and the Big West Production Company, Klein being president and manager of both concerns, and Vaughn secretary and treasurer. **C. S. SANDERS,** who has been assistant general superintendent, succeeds Klein. **M. C. HOFFMAN** takes over Sanders' old post, and **D. G. SAFFORD** becomes Hoffman's assistant.

E. L. STAUFFACHER, superintendent of construction and operations, has been transferred from Bartlesville, Oklahoma, to Chicago, where he will be in charge of all engineering work for the Cities Service Oil Company (Delaware), according to an announcement by **H. R. STRAIGHT,** vice-president and general manager of the Empire Oil and Refining Company. **H. A. ELLS,** a co-superintendent with Stauffacher, has been promoted to the newly-created job of general superintendent of the gasoline division, Empire Oil and Refining Company. **RALPH W. JOHNSTON,** superintendent of the gasoline plant at Tallant, Oklahoma, has been transferred to Bartlesville and made assistant superintendent of the gasoline division in charge of construction.

J. A. de LANOY, chief purchasing agent of the Asiatic Petroleum Corporation, has been elevated to Knighthood in the Order of Oranje Nassau by Her Majesty Queen Wilhelmina of The Netherlands.

F. H. BAILLY, production superintendent for the Pantepec Oil Company, Caracas, Venezuela, has been visiting his home in California.

C. M. HOUCK, formerly manager of the inspection division of the Pittsburgh Testing Laboratory, Pittsburgh, Pennsylvania, was elected vice-president at a recent meeting of the board of directors. His predecessor in the vice-presidency, **A. R. ELLIS,** recently was elected president.

J. P. HULL, who has been with the Trinidad Petroleum Development Company, has been made drilling superintendent of the Antilles Petroleum Company (Trinidad), Ltd.

I. B. BOYCE has been appointed assistant manager of the West Scotland Branch of the Shell-Mex and B. P., Limited.

R. W. LOWE, Shreveport, Louisiana, general superintendent of the production department of the Standard Oil Company of Louisiana since 1922, has retired following 26 years of service with the company.

CONRAD J. KERST has been transferred by the Venezuela Gulf Oil Company from Lake Maracaibo to eastern Venezuela, where he is in charge of the warehouse.

DR. M. R. FENSKE, director of the Petroleum Refining Laboratory at the Pennsylvania State College, has been made head of the Division of Industrial Research at the same institution.

S. E. WILSON, JR., independent operator of Houston, Texas, has moved his headquarters to Corpus Christi, in which area he has considerable production.

W. P. COX, petroleum engineer of the Western Gulf Oil Company, who has been stationed in California, recently was transferred to Venezuela and made assistant to **C. C. GHIO,** who is in charge of drilling operations in eastern Venezuela.

W. G. PRINCE, superintendent of production of the Stanolind Oil and Gas Company for the Beaumont, Texas, division, has been transferred to Lake Charles, Louisiana, where he is in charge of production.

A. C. JOHNSON, Calgary, Alberta, Canada, has been elected president of the Anaconda Oil Company. **O. L. REINECKE** was chosen first vice-president, **J. T. ATKINSON,** second vice-president, and **A. J. SCOTT,** managing director and secretary-treasurer.

R. D. ROBEY, Tulsa, Oklahoma, has entered business for himself as a drilling contractor. He formerly was with the Olson Drilling Company.

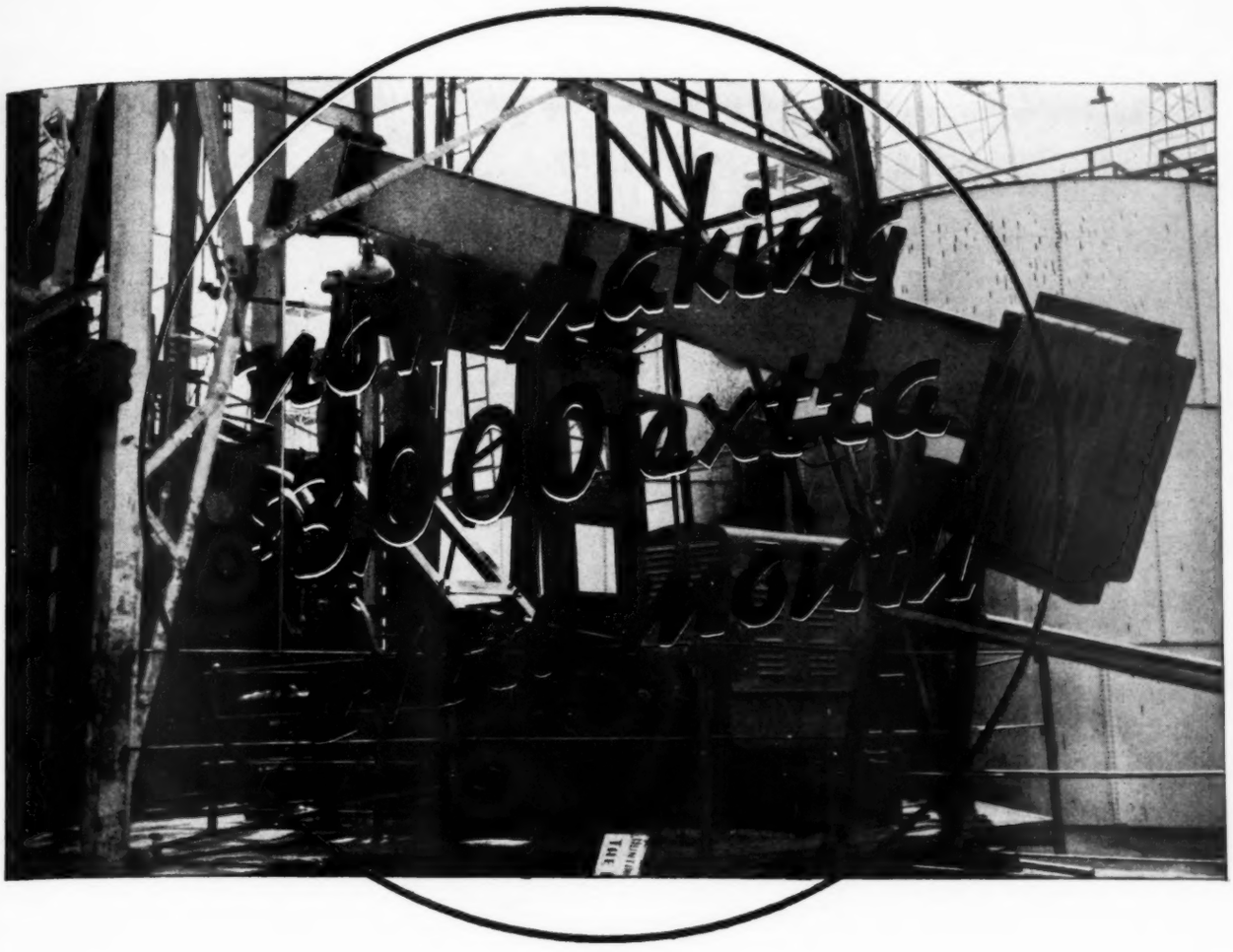
ALBERT F. SCHULTE, manager of the right-of-way department of the Standard Oil Company of California, has retired. He has been in active service with the company for 35 years. **SAMUEL W. SELFRIDGE,** who has been Schulte's assistant, has been promoted to head the department.

P. V. SMITH, who for many years was with The Texas Company, and also operated as an independent in Jack and Archer counties, Texas, as well as being with various companies in foreign fields, is now connected with the National Schools, who give training in Diesel and gas engineering. He recently established his office at 508 Burt Building, Dallas, Texas.

W. A. SNIFFEN, assistant manager of the Magnolia Pipe Line Company, will retire March 1st, following 23 years of service. He joined the Magnolia's pipe line department January 7, 1914, coming to Texas from Marietta, Ohio. He has been assistant manager since 1932, and in 1933 also was selected a director of the Magnolia Pipe Line Company and the Magnolia Petroleum Company.

DAN WILLIAMS, JR., assistant petroleum engineer at Rodessa, Louisiana, for the Magnolia Petroleum Company, has been transferred to Talco and the East Texas fields. He has been succeeded at Rodessa by **LESTER DANIEL,** recent graduate petroleum engineer of the University of Oklahoma.

W. M. THORNBURY, superintendent for the British Oil Company at Mosul, Iraq, recently visited his family in Pasadena, California.



Good hard spendable dollars . . . the kind you can see, and put in the bank . . . 3000 of them. That's what the increase in production amounted to for one month after a California operator replaced a standard outfit with a Long Stroke Unit.

Conditions under which the unit operates makes this performance even more remarkable. The well was whipstocked on a 45° angle at 700′ and the pump, which is set at 3750′, is 2400′ off the vertical line. A tough job, for sure, but the Long Stroke Unit was built to handle the tough ones.

Why not be sure that *you* are not passing up extra profits like these? It will cost you nothing to find out . . . a phone call to your nearest Parkersburg representative is all that is necessary.

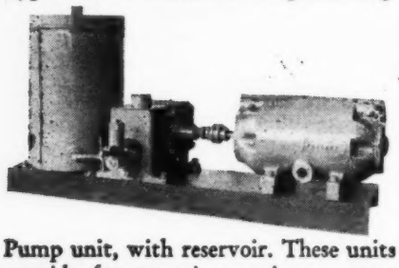
Be sure and ask for our new catalog on Parkersburg Long Stroke Units. It contains full information on everything you want to know about this new revolutionary pumping principle.

The PARKERSBURG RIG & REEL Co.
Parkersburg, West Va.
DALLAS - HOUSTON - TULSA - LOS ANGELES - NEW YORK
Branches In Every Active Field

MACHINERY and EQUIPMENT

Reed Rotary Engine

A new rotary engine, for use with compressed air or gas, has been announced by the Reed Roller Bit Company, Houston, Texas. The accompanying illustration shows the Type No. 1 Chemical Proportioning



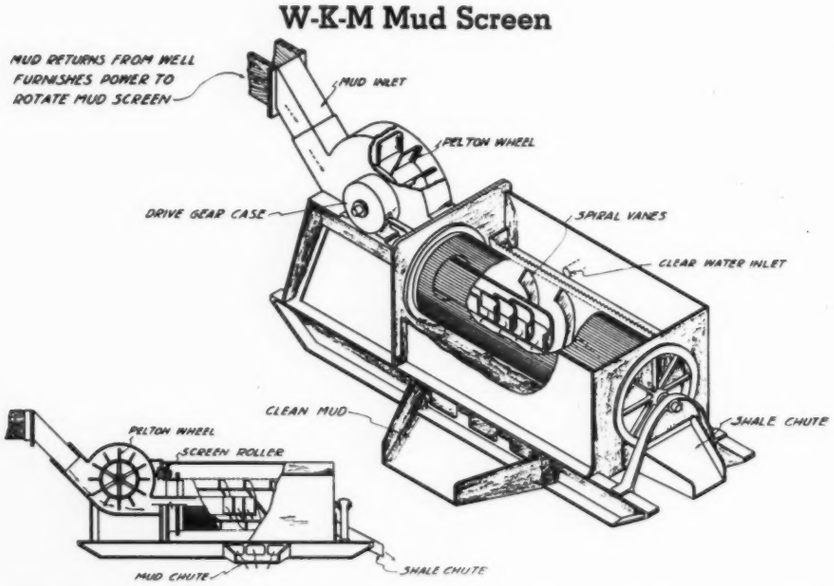
Pump unit, with reservoir. These units provide for pumping against a great range of well pressures and the amount of chemical pumped may be adjusted to any value.

These engines will operate at pressures up to 300 lb. per sq. in. and at speeds up to 2000 revolutions per minute. Satisfactory operation may be had at any pressure between two lb. per sq. in. and 300 lb. per sq. inch. With but 45 lb. per sq. in. pressure these engines will develop one horsepower.

Due to their use of gas from wells, which otherwise would be wasted, they have found favor as a prime mover for pumps for circulating salt water, etc., the manufacturers state. Other suitable uses are for driving lubricators, rotary circulating pumps, centrifugal pumps, bug blowers, etc.

The Reed Rotary Engine, Type No. 2, for use with either air, gas, or steam also is offered. These engines, in addition to the uses for the Type No. 1 engine, are very suitable for driving shale shakers, light hand reels, etc.

W-K-M Mud Screen



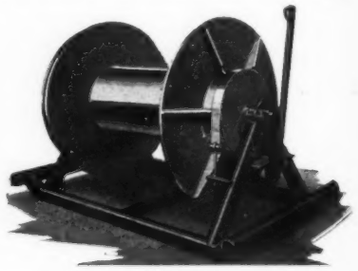
THE W-K-M Mud Screen, here illustrated, employs a new principle of design and operation, eliminating much of the usual expense for maintenance and parts, according to the manufacturers.

This screen is driven by the flow of the mud returns from the well, and does not require any steam turbine, electric motor, or other source of motive power.

Separation of the shale and cuttings from the mud is accomplished by a slow-speed, combination vibrating and rotating motion of the screen proper. The absence of excessive vibration, or other violent means of operation, makes frequent replacement of the screening wire unnecessary, and naturally prolongs the life of the unit, it is stated.

Bridgeport Wire Line Spooling Device

THE Bridgeport Machine Company, of Wichita, Kansas, has developed and placed on the market a mechanical wire line spooler designed to improve the conventional method of installing and removing the drilling line from the bull wheels. The unit consists of a flanged-steel drum, mounted on alemite lubricated bearings in a steel skid frame, which is fastened

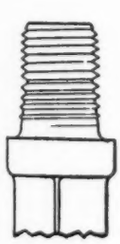


to the derrick floor by attaching chain and boomers to the loops at the front and rear of the frame. It is driven by a bull rope tug rim on the drum flange or from a sprocket wheel attached to the extended shaft. A friction-type, adjustable brake is controlled either from the driller's position at the throttle or by a hand brake lever in front of the unit.

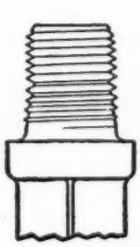
It is claimed that when spooling or unspooling, the tension on the wire line is under positive control, so that the likelihood of twisting or kinking the line is minimized greatly and that the wire is spooled tightly, evenly, uniformly, and rapidly on the drum. It is claimed that the hazards and dangers of injury to crew and equipment are practically eliminated and that the operation of unspooling is rapid, safe, convenient; and that the unit is especially convenient to load, and handy to haul from location to location. Complete information may be obtained by writing the Bridgeport Machine Company, Wichita, Kansas, or any of the company's branches, for Bulletin No. 71.

"Let's talk about sucker rods."

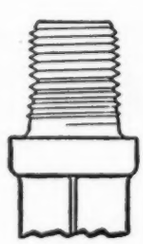
Keeping our minds strictly on business, we can't help but feel that the thing which interests an oil producer most is sucker rods that stand up on the job. Today, as never before, sucker rods are being designed, developed and manufactured to most economically meet the needs of oil producers. Only by a careful study of respective claims and by actual use of the product, can any purchaser hope to determine the rod best suited for use in his wells. Axelson honestly believes that the background of experience possessed by every member of its organization is a reasonable consideration for the use of Axelson Rods —IN ANY WELL, IN ANY LOCALITY, and UNDER ANY CONDITION. Today Axelson offers the trade three grades of sucker rods, not because more could not be produced, but because more would be unnecessary. In one of these rods, differing from the others in price, in physical characteristics, in economical properties, will be found the best solution to your sucker rod problems. Ask any Axelson representative to tell you how these rods were designed and manufactured to the oil producer's exact order.



Axelson No. 60 Sucker Rods are made from exceptionally high grade carbon steel under strict alloy practice. They are fully tempered from end to end assuring consistent physical properties. The ductility and impact resistant properties of these rods is such as to indicate their practical use for all average to heavy pumping conditions.



Axelson No. 59S Sucker Rods made of special alloy steel that materially aids their resistance to corrosion, are fully normalized and tempered from end to end. They present excellent physical properties, combining increased ductility and impact resistance with high yield and tensile strengths. They are desirable for pumping wells where extra heavy loads are encountered and where irregularities in pumping movements are unavoidable.



Axelson No. 69 Sucker Rods are made from a high alloy special nickel molybdenum steel produced in electric furnaces. These rods are especially resistant to corrosion, are fully normalized and tempered from end to end. They offer excellent yield and tensile strengths, with great ductility and impact resistant properties.

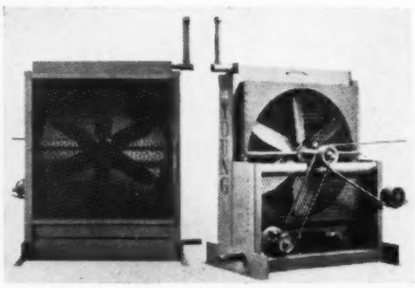
Axelson Manufacturing Company, P. O. Box 710, Vernon Station, Los Angeles • St. Louis • 50 Church Street, New York • Tulsa
Mid-Continent and Eastern Distributor: Frick-Reid Supply Corp. • *Rocky Mountain Distributor:* Great Northern Tool & Supply Co.

DEEP WELL PLUNGER PUMPS **AXELSON** SUCKER RODS

Self-Contained Cooling Unit

A NEW type self-contained cooling unit for cooling engines in oil field service is announced by the Young Radiator Company, Racine, Wisconsin.

The new unit, shown in the accompanying illustration, contains all devices needed for circulating both air and water—complete fan equipment, pump, and idler. The fan is 6-bladed, 36-in. diameter. The water capacity in top and bottom tanks is 12.6 gallons. Overall dimensions are: Width 54 in., height 58 in., depth (front to rear) 33¾ inches. Weight of the complete unit, dry, is 642 lb.; full, 747 pounds.

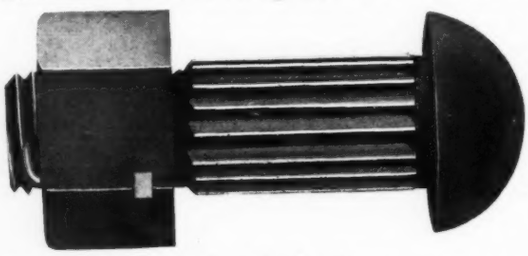


Construction consists of channels, angles, pipe, and plate fused into an integral unit by electric welding with shielded arc equipment supplied by The Lincoln Electric Company, Cleveland, Ohio. The fan guard screen, at front and rear, is ⅛-in. steel wire mesh arc welded to the frame. The sheave is 6⅛-in. diameter, 4-groove for belt drive. The inlet and outlet pipes are 1½-in. diameter.

The new cooling unit is manufactured in two sizes, each equipped with different core specifications to take care of cooling engines of 35 to 125 horsepower.

Structural Rib Bolt

THE Structural Rib Bolt, used with the Anco-Nut, is announced by the Automatic Nut Company, Inc., of Lebanon, Pennsylvania, as a practical substitute for riveting. Both the Structural Rib Bolt and the Anco-Nut have U. S. standard threads and can be galvanized without affecting the locking feature, the manufacturers state. The only equipment necessary for erection is hand hammer and wrench.



The locking feature is pointed out by the makers as being a very important part of this equipment. The end of the locking pin travels between the threads of the bolt. In so doing the pin automatically assumes a fixed angle, and establishes a point of impingement against the bolt—the pin biting into the body of the bolt and thus maintaining an anchorage against vibration and shock. This impingement actually acts as a ratchet, moving up and taking a new bite as the nut is drawn tighter, but always resisting and preventing the nut moving in the opposite direction, that is, becoming loose.

Keystone Model 18A Excavator

ACCURACY of control is an outstanding feature in the new Keystone Model 18A One Yard Excavator, manufactured by the Keystone Driller Company, Beaver Falls, Pennsylvania. The use of planetary drives and over-size clutches, designed for efficient operation in service necessitating constant slippage of the clutch for long periods of time, plus smooth, easy control with the same lever system that has always been so desirable in steam-powered machines, are largely responsible for the greater accuracy with which the machine can be operated, the makers state.

The machine is built for a wide variety of digging, having one boom that is used in both trench hoe and skimmer service and to which a short extension may be attached for short boom, crane service. The machine also is available with a boom for dragline, clamshell, and crane.

Built-In Qualities in JENSEN JACKS

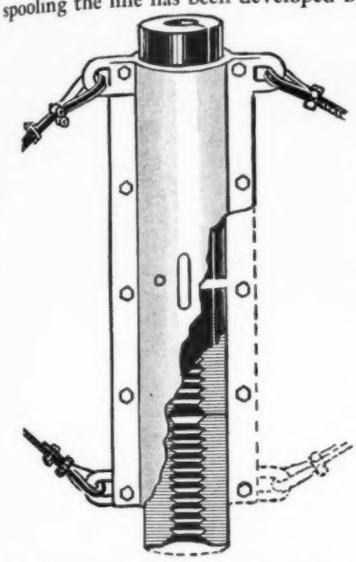
NINETEEN YEARS in the manufacture of pumping equipment have taught us how to build Dependability, Economy and Efficiency into JENSEN Straight-Lift JACKS, just like we build in the bearings and other essential parts.

See Your JENSEN Dealer — or write us at Coffeyville

JENSEN BROTHERS MANUFACTURING CO.
. . . . *Coffeyville, Kansas*

Wire Line Guide

A NEW type wire line guide that is claimed to be fire-proof and spark-proof and effective in properly spooling the line has been developed by



the Patterson-Ballagh Corporation of Los Angeles. This guide has an elongated rubber bushing that is said to eliminate hazardous sparks because the wire line does not develop a metallic contact but is cushioned by the rubber. The guide consists of a resilient member, compactly housed within a metal container that permits free travel of the wire line for proper positioning of the line on the spool. The resilient lining or bushing is made from identically the same wear-resisting rubber as used in Patterson-Ballagh casing protectors.

By use of this guide, according to the manufacturers, the wire line is spooled evenly, preventing piling up of the line on the spool.

Asbestos Cord Steam Hose

THE U. S. Royal Asbestos Cord Steam Hose Official P-6031, a new addition to its line of steam hose, has been announced by U. S. Rubber Products, Inc., New York City. The new hose is expected to find its most important uses in oil refineries. Its makers claim that it has a non-deteriorating, non-char carcass, is adaptable to super-heated high-pressure steam service, is of light weight, and flexible.

The hose is constructed of quality steam and heat-resisting rubber tube; four plies of high-strength asbestos cords wound spirally in alternating directions; cords cushioned in a layer of rubber and wrapped in a heat-resisting rubber cover. It is made four ply in ½-in., ¾-in., 1-in., 1¼-in., and 1½-in. I.D. sizes, accommodating pressures ranging from 175 lb. to 200 pounds. Maximum lengths are 50 feet.

MAC CLATCHIE WEAREVER PUMP PISTONS

Only IN MacCLATCHIE WEAREVER PUMP PISTONS do you get these features:

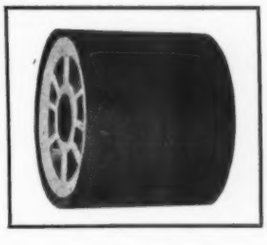
● REPLACEABLE RUBBERS—Lower Operating Costs

The MacClatchie Wearever Pump Piston is renewed at the well without changing the center spool or end plates, but simply by installing new rubbers. This feature effects a remarkable saving over 1-piece pistons as the cost of the replacement rubbers is only a fraction of the original investment.

● LINER PROTECTORS—Longer Life for Liners

All the steel parts in the MacClatchie Piston are separated from the liner by either the Piston Rubbers or the Liner Protectors. These Liner Protectors are "L" shaped brass rings, vulcanized securely to the back side of the rubbers, and when assembled overlie the steel center of the piston, thereby protecting both the liner and the piston —greatly prolonging the life of each.

These two features can be had only in MacClatchie Pistons. Operators the world over are finding that MacClatchie Pistons effect a large saving in their piston and liner costs. A trial will also convince you. In competitive tests by leading oil companies MacClatchie Pistons have consistently outrun other makes. Order a set today and get the longer life and greater economy of this superior product.



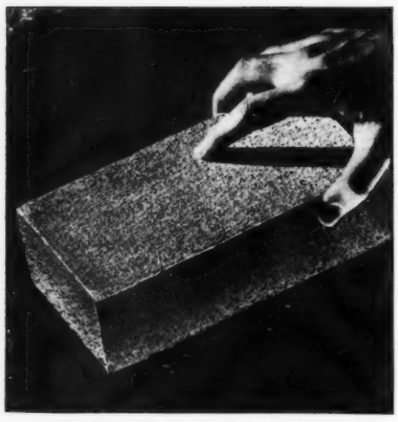
Sold by all leading supply houses

MacCLATCHIE MANUFACTURING COMPANY

COMPTON, CALIFORNIA HOUSTON, TEXAS

Export: GEO. R. WOODS, 17 Battery Place, New York

Johns-Manville Announces Insulating Brick



JOHNS-MANVILLE recently placed on the market a new type of 2000-deg. insulating brick known as "JM-20." This new brick, fully protected by Johns-Manville owned patents, was developed by the company's research laboratories for use behind refractory walls in cracking furnaces and other types of high-temperature industrial equipment. It also can be used for direct exposure at temperatures up to 2000 deg. fahr. wherever there is no flame impingement, slag action, or mechanical abrasion, the manufacturers state.

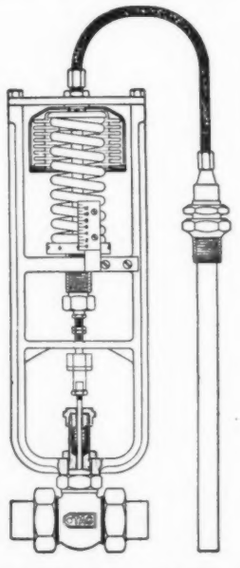
Research on basic raw materials used in refractory insulations led to the development of JM-20 insulating brick. This new type of insulating refractory is produced by combining a high-quality refractory clay with a specially-manufactured, fibrous, lightweight, inorganic aggregate.

JM-20 insulating brick is unusually light in weight, weighing less than 1.7 lb. per standard 9-in. equivalent. Its heat capacity is unusually low, less than one-quarter that of ordinary refractories, and its thermal conductivity is less than one-sixth that of fire brick, according to the makers.

Data sheets giving full particulars on JM-20 insulating brick may be obtained from any Johns-Manville office.

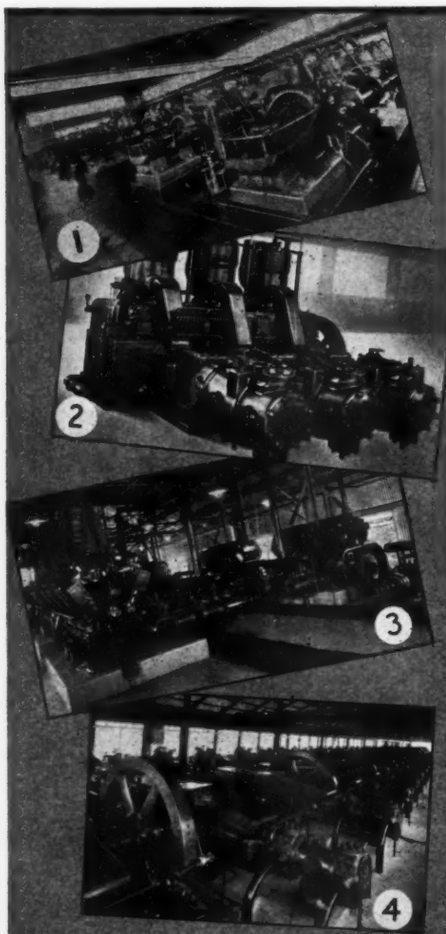
TAG Self-Operating Controllers

C. J. TAGLIABUE Manufacturing Company, Park and Nostrand Avenues, Brooklyn, New York, announce improvements in their 30-year-old line of self-operating temperature controllers. These improvements include an entirely new design of flexible seamless metal bellows and numerous minor refinements of design, material, and workmanship.



This new model is suitable for industrial applications where the close control obtainable with auxiliary power is not necessary or where the steam pressure available is less than 10 lb. per sq. in. (necessary for opening the Tag steam-operated controller). Temperature ranges are approximately 75 deg. between the limits of 30 deg. fahr. and 450 deg. fahrenheit. The valves are semi-balanced, in sizes from ½ in. to 2 inches.

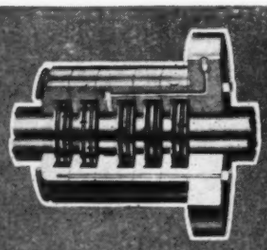
Seal your reciprocating piston rods
the way so many engine and compressor builders do . . . with
COOK'S METALLIC PACKINGS



Any engine or compressor is a more efficient unit if its rods are fitted with COOK'S METALLIC PACKING. The leading engine builders recognize this fact. Noteworthy applications are represented by the equipment, shown in the accompanying illustrations, that comes factory-equipped with COOK'S PACKINGS.

There is an approved type for all pressures fitted with packing rings made of COOK'S GRAPHITIC IRON, Cookmet, Babbitt or Micarta, as the requirements of service suggest.

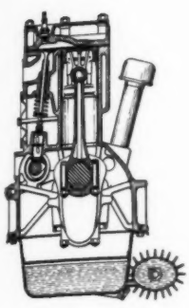
For existing equipment, communicate with us direct or our nearest branch office.

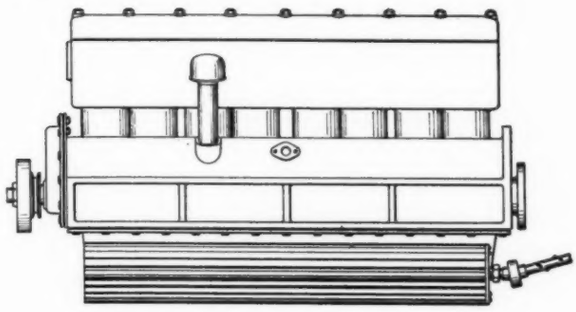


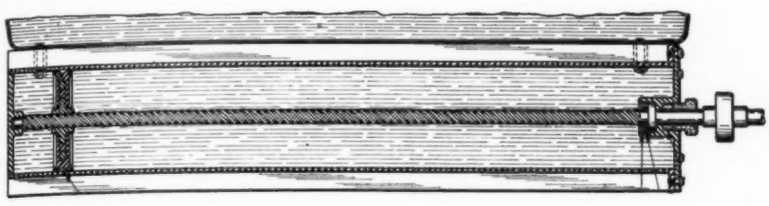
1-COOPER-BESSEMER CORP.
2-CLARK BROTHERS COMPANY
3-INGERSOLL-RAND COMPANY
4-WORTHINGTON P&M CORP.

C. LEE COOK
MANUFACTURING CO.
INCORPORATED
LOUISVILLE, KY.
NEW YORK • LOS ANGELES • CHICAGO
NEW ORLEANS • CLEVELAND • TULSA
BALTIMORE • SAN FRANCISCO

Oil Exchanger and Cooler







L. D. Hilton, 711 Milby Street, Houston, Texas, has announced a fast operating oil exchanger and cooler for application to the crank case of internal combustion engines. The device is applicable to the engine of motor cars, motor trucks, or any other gas, gasoline, or Diesel prime mover, he states.

The purpose of the device is to provide a highly efficient means for controlling the temperature of lubricating oil in the crank case. Operation of the device may be either manually, mechanically, or by means of a thermostat. Control lever of the manually-operated type oil exchanger and cooler is placed under the dash or on the instrument panel of the automobile or truck. A few turns of the lever exchanges the cool oil content of the exchanger cylinder for an equivalent values of hot oil from the crankcase pump. Hot oil taken into the exchanger cylinder is cooled quickly, heat being dissipated through a series of radiating fins made integral with the outside of the cylinder.

Harnischfeger Announces Line of Simplified Welders

THE Harnischfeger Corporation, Milwaukee, Wisconsin, announces a new line of simplified P. & H. Hansen "Smootharc" welders featuring single current control, self-excitation, and internal stabilization, the qualities so necessary for fast, steady welding, deep penetration and uniform metal deposit. This new line of welders is constructed in two styles vertically mounted in 75, 100, and 150 amp. capacities, and horizontally mounted in 200, 300, 400, and 600 amp. sizes. Both models are uniformly and compactly built, streamlined to eliminate projecting parts and to permit easy portability.

STRIP—PIPE LINES ECONOMICALLY

with the

CLEVELAND

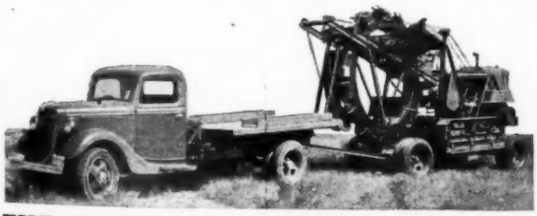
"MODEL 110"

Dig Anywhere—Anytime

Not the least of the many features of the Cleveland "Model 110" which stamp it as foremost in Ditcher Value, is its ability to uncover pipelines, for removal or repair.

Last year, this was demonstrated on hundreds of miles of welded, screw and Dresser lines with very important cost savings; both under "wholesale" and "piecemeal" reconditioning methods.

Cleveland's ability to accurately follow the line, with minimum interference to couplings, collars, saddles, etc., and to expose the pipe so that little or no work was required before raising, was noteworthy. On "piecemeal" jobs, their Trailer-Mobility permitted them to travel with the gang from spot to spot at practically no additional expense.



Fast, tough, modern and durable, you'll find "Clevelands" the realization of what a ditcher ought to be. Let us furnish you with information.

Another important "Cleveland" idea is the fast low-cost transportation via special trailer. Loads or unloads in 10 to 15 minutes—making available machine-savings on even scattered short lines, "hot-spot" reconditioning, etc.

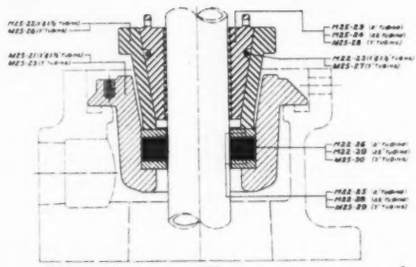
THE CLEVELAND TRENCHER CO.—20100 St. Clair Avenue, Cleveland, Ohio

CLEVELANDS

"Oilwell" Type 36 Tubing Hanger

THE "Oilwell" Type 36 tubing hanger provides a safe, simple, and inexpensive means of support for a string of 2-in., 2½-in. or 3-in. tubing (plain or upset), according to the manufacturers, the Oil Well Supply Company, Dallas, Texas. It is intended for use with a common or Berry pattern casing head with 8½-in. diameter recess.

Simplicity is the keynote of the Type 36 tubing hanger's construction. There are only four major parts—slip body support, slip body, slip assembly, and



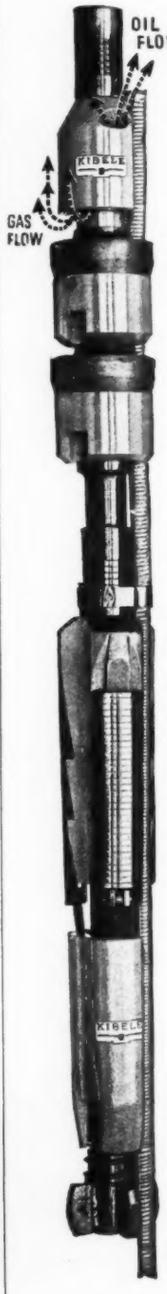
packing element. The arrangement of these parts is illustrated in the accompanying drawing.

The semi-steel slip body support is provided with two tapped holes for lifting eyes and its outer edge is beveled so that it can be anchored by means of setscrews.

The packing element consists of top and bottom pressed-steel rings and rubber ring. For convenient installation and removal, the steel rings are split into halves and the rubber ring is supplied in one piece but split diagonally. The slip body is a bowl-shaped steel casting that rests on the packing element.

Flow Head Packer and Tubing Catcher

A FLOW HEAD PACKER that the manufacturers claim can be assembled completely anywhere in the tubing string and through which it is not necessary to thread the cable while running into the well is one of the latest Kibele tools. This packer has been devised especially for use with electric-driven centrifugal pumps.



Metal bowls and rubber cups are split, the cups packing off the cable as well as casing and tubing. The cable sets in close to the tubing and does not rub the casing.

The flow head of this packer delivers oil from the pump into the casing at a point above that at which the gas flow enters, thus increasing efficiency of the unit. Oil flow and gas flow passages are of the same area as the tubing and permit unrestricted outlet through the packer.

The device packs off by means of fluid pressure. Its mandrel offers no reduction in the internal area of the tubing. In the center of the flow head is a bridge that can be broken if access to the bottom of the tubing is necessary.

This packer is not anchored in the pipe, can be lowered or raised and pulled from the well easily.

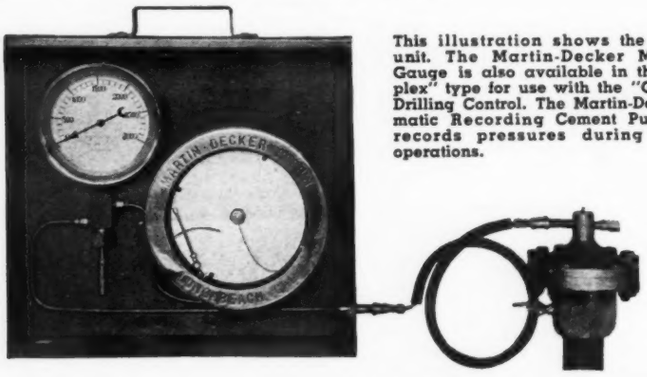
Metal bowls and rubber cups that are not split or made to accommodate the cable also are supplied so that the packer can be used for straight gas-lift work.

Know
YOUR SLUSH PUMP PRESSURES
for
today's drilling & tomorrow's reference!

The DRILLER *knows* Slush Pump pressures when he is using the Martin-Decker Non-Clog Slush Pump Gauge, because he can *see* the pressure. By the same token he can *see* a hole in the drill pipe, pumped out tool joints, the condition of the pump valves and pistons. In fact, he *sees* a complete, dependable picture of the entire mud circulating system.

The ENGINEER *knows* Slush Pump pressures, too, when the rig is equipped with Martin-Decker Non-Clog Slush Pump Gauge, because he can *read* them from the charts taken from each day's drilling record. He *reads* equipment breakdowns such as pipe "twist-offs," failures of hose, fittings, pumps, pump parts, etc. He can definitely check equipment performance.

The OPERATOR *profits* because equipment failures are lessened by virtue of the information furnished by the Mud Pump Gauge.



This illustration shows the individual unit. The Martin-Decker Mud Pump Gauge is also available in the "Quintuplex" type for use with the "Quintuplex" Drilling Control. The Martin-Decker Automatic Recording Cement Pump Gauge records pressures during cementing operations.

THE WEIGHT INDICATOR
MARTIN-DECKER CORPORATION
LONG BEACH CALIFORNIA
San Joaquin Valley: A. F. McQUISTON, Bakersfield, California
Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

Vernon Tool Appointments

Vernon Tool Company, Ltd., Los Angeles, California, announces the appointment of Ward Blackburn as vice-president and manager, and John H. Suter as chief engineer.

WARD BLACKBURN

Blackburn for the last 20 years has been manager at Los Angeles for Ingersoll-Rand Company. He has been closely identified with the California oil and gas industry and has directed the sales, installation, and service of a large percentage of the compressor and pumping plants now in operation.

JOHN H. SUTER

John H. Suter is well known to the industry. He was chief engineer for the Western Gas Engine Company and the Western Machinery Company for 12 years. Later he formed the Suter Gas and Diesel Engine Company.

Fluor Opens Houston Office

The Fluor Corporation, Ltd., with headquarters in Los Angeles, California, has opened an office in the Esperson Building, Houston, Texas. O. L. Carson is in charge.

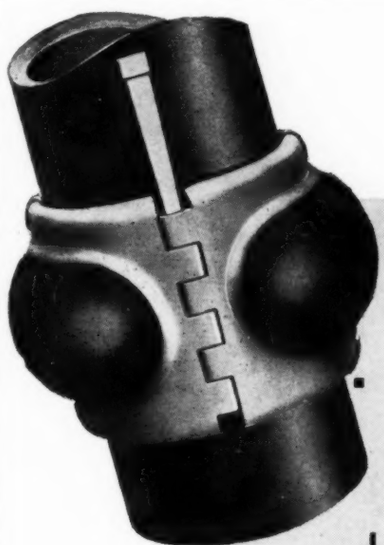
Pool Well-Logging Patents

Schlumberger Well Surveying Corporation and International Geophysics Company have announced the pooling of their well-logging patents in order to give their customers the full benefit of their separate experiments and studies. As in the past, all work in open holes will be handled by Schlumberger Well Surveying Corporation, and the International Geophysics Company will limit its activities to perfecting its method of logging cased holes.

Mission Manufacturing Co. Holds Sales Meeting

The Mission Manufacturing Company recently held a sales meeting in Houston, Texas, at which its representatives from all parts of the United States were present. As a part of the program a dinner was given at the Houston Club.

At the meeting a new setup in the sales organization was announced. W. T. Campbell, formerly vice-president and treasurer, was made vice-president and general sales manager. J. D. Best, formerly West Texas sales representative, was made Campbell's assistant.



The best you can get

. . . EVERYTHING

you want . . . in

drill pipe protectors

GRIZZLY

When it comes to drill pipe protectors the best you can get - - GRIZZLY - - have EVERYTHING you want - - An unyielding grip that eliminates slipping, piling up, and overlapping . . . Simple hinge and key lock design that makes application and removal quick and easy . . . Strength of metal and toughness of rubber that assures worthwhile savings through longer life.

A BEAR FOR WEAR

E. M. SMITH COMPANY

600-650 South Clarence St. Los Angeles, Calif., U.S.A.

Sold in the Mid-Continent and Gulf Coast by: Continental Supply Co., T. T. Word Supply Co., Houston, Texas — In All Their Stores: Independent Pipe & Supply Co., 2311 West St., Houston, Texas

Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City

B. V. Fisher Joins O-C-T

B. V. Fisher, for the past four years a special field representative for Continental Supply Company, has accepted appointment as assistant sales manager for Oil Center Tool Company, Houston, Texas. Under supervision of A. J. Penick, president and sales manager, Fisher will have charge of the O-C-T sales force. His experience in the oil country began with Westcott Valve Company 11 years ago. At the time he left Westcott to join Continental Supply Company he was assistant sales manager, covering all U. S. fields.

B. V. FISHER

S. M. Jones Opens Southern Division Office

The S. M. Jones Company of Toledo, Ohio, and Tulsa, Oklahoma, manufacturers of JoneSuckeRods, have announced the opening of a Southern Division office in the Dallas Bank and Trust Building, Dallas, Texas. This new division is in charge of L. J. Pundt, division manager, and comprises the entire state of Texas, excluding the Panhandle, plus the states of Arkansas, Louisiana, and New Mexico.

L. J. PUNDT

The purpose of this move, according to P. C. Jones, president, is to effect a better coördination of the company's increasing field engineering and sales activities in the southern Mid-Continent oil fields.

District representatives in charge of the various territories making up the division will be C. E. Buchner, in charge of the Gulf Coast; J. R. Hughes, in charge of the North and West Texas territory; and J. G. Litherland, in charge of East Texas.

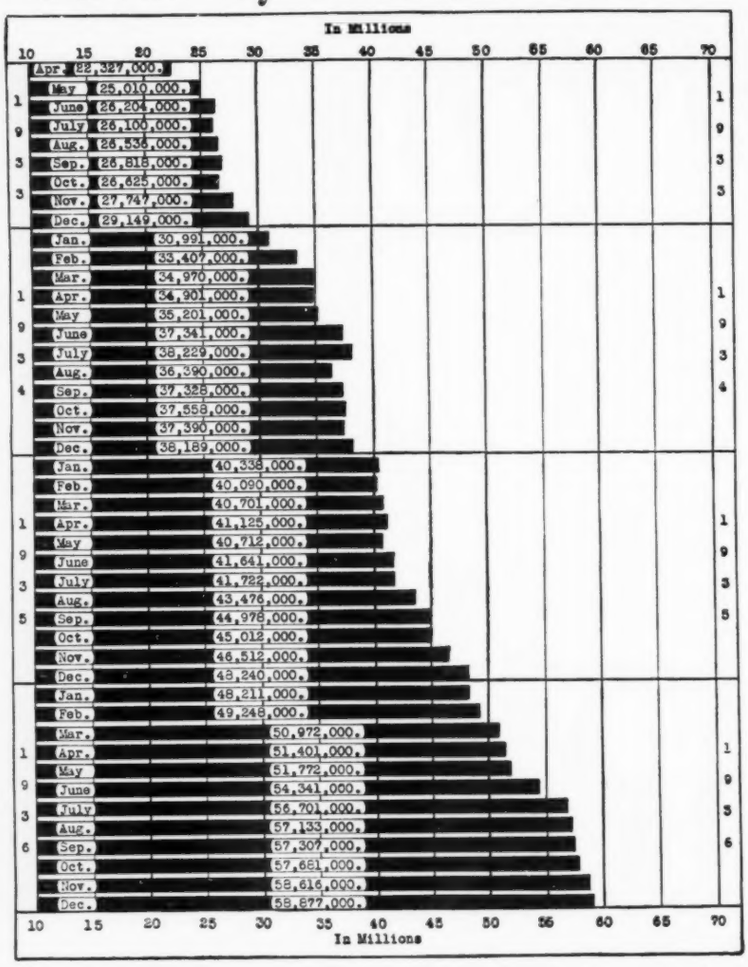
The company also announces the appointment of C. W. Turner as district representative, in charge of the Louisiana-Arkansas territory. Turner studied engineering at the University of Oklahoma and is thoroughly experienced in sucker rod pumping problems, having been connected with the company's field engineering department in Tulsa.

Leaf to Cover West Texas for BJ

Gordon Leaf, of the Byron Jackson Company sales force, has been stationed at Odessa, Texas, to cover West Texas with BJ oil tools.

BANK'S 155% GAIN

Shown by Effective Chart



Since its organization in April, 1933, deposits have climbed steadily upward to make this bank FIRST IN OKLAHOMA. Individuals and Business are offered select service for their needs.

NATIONAL BANK OF TULSA

Member Federal Deposit Insurance Corporation

International Derrick Conference at Beaumont

A two-day conference of Mid-Continent and Gulf Coast salesmen recently was held at Beaumont, Texas, by The International Derrick and Equipment Company. E. H. Eddleman, vice-president in charge of sales, directed the activities of the conference. The main address was given by L. J. Brown, president of International-Stacey Corporation, of which The International Derrick and Equipment Company is a division. B. S. Wellman, executive vice-president and director, was the principal speaker at the banquet. Other executives and department heads lead discussions on various topics. Many new products were introduced during the meeting, as well as improvements in existing equipment. Plans were made for an expanded sales and advertising program during the coming year.

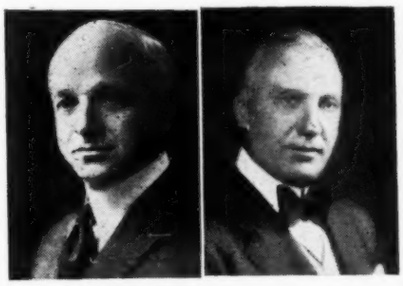
Reading from left to right, front row—L. L. Powell, C. M. Powell, C. G. Booker, B. S. Wellman, director; L. J. Brown, president; B. Boykin, jr., director; E. H. Eddleman, vice-president; J. M. Aitken, C. R. Athy, E. H. Jensen, L. R. Spencer. Back row, left to right—Larry Waterbury, jr., A. P. Texada, jr., F. E. Anderson, F. W. Ulin, R. Lee Chance, C. D. Lambert, J. A. Tidball, Cobb Turner, E. C. Skinner, L. C. Bodemann, P. E. Suder, Charles E. Hamlin, D. D. Perry, M. T. McGriff, Dan A. Fell, T. F. Neeson, D. D. Deason, G. E. Shoup, William O. Cook, Tom Bergin, W. S. McEwen, C. A. McClelland and C. J. Colby.

New District Managers Appointed by Crane Co.

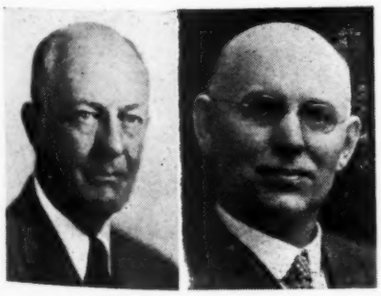
C. S. PITKIN

Crane Company announces the establishment of two new sales districts—the East Central and the Southeastern — in charge of C. S. Pitkin and J. G. Johns, respectively. Pitkin has been manager of the Pittsburgh branch since it was established in 1922, and Johns, at Birmingham, since 1920. Other changes in local branch management are as follows:

H. M. Moss, sales manager at Pittsburgh, succeeds Pitkin as branch manager. F. D. Morrison, assistant manager at Birmingham, becomes manager, succeeding Johns. F. W. Zander, manager at Buffalo, retires from active management. G. E. Anderson, manager of Lima branch, has been transferred to



F. W. ZANDER S. S. DAY



J. G. JOHNS H. L. WOOD

Buffalo as Zander's successor. E. R. Henning succeeds Anderson at Lima. The retirement of H. L. Wood, Sioux City, Iowa, moves T. R. Brady, manager of the Rockford, Illinois, branch to Sioux City as manager, and R. E. Doherty, sales manager at the Portland, Oregon branch, is made manager at Rockford. S. S. Day, manager at Sacramento, California, has asked to be relieved of active duty, to be succeeded by E. B. Moor. E. T. Rowe, formerly manager of Syracuse branch, has been appointed manager of the Boston branch, succeeding T. H. Dawson, Jr. A. H. Buck, assistant manager at Pittsburgh succeeds Rowe.

Wanted — ELECTRICAL ENGINEER — Must be college graduate in electrical engineering. Very desirable that applicant have experience in instrumentation. State degree received, school attended, past experience, age and send photograph if available. Address Box 10, The Petroleum Engineer, Allen Building, Dallas, Texas.

COME TO HOUSTON

Enjoy THE BEST IN LOW COST Luxury

Here's a tip! For a pleasant stay in Houston, stop at the Texas State. You will enjoy everything about this hotel from the moment you enter. It's a refreshing and welcome relief, yet it costs you no more than ordinary hotels.
The Texas State is Houston's newest, most modern hotel.. Both tub and shower in every room. Next time you're in town, try the Texas State.

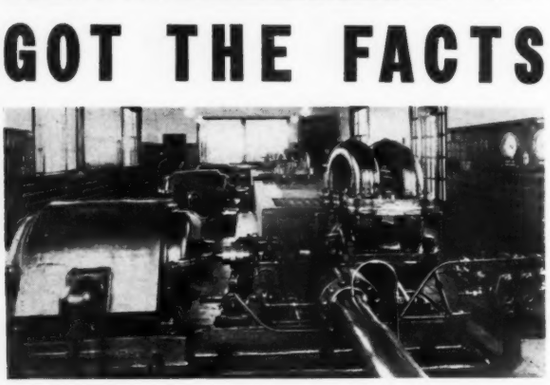
LOW AS $2.50 PER DAY

TEXAS STATE ★ HOTEL ★

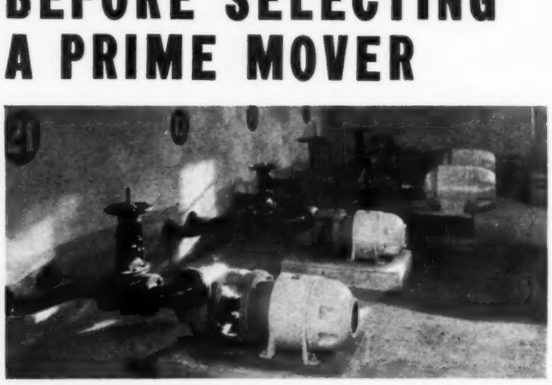
B. F. ORR General Mgr.

THESE COMPANIES

GOT THE FACTS



BEFORE SELECTING A PRIME MOVER



THEY CHOSE

PURCHASED ELECTRIC POWER...

Phone Your Power Company.
An Engineer . . not a
Salesman . . will call.

PETROLEUM ELECTRIC POWER CLUB

TRADE LITERATURE

AN ATTRACTIVE BOOKLET ENTITLED, *"Fairbanks-Morse Diesels,"* has been issued, illustrating and describing present models in the complete line of Fairbanks-Morse Diesel engines. An introduction traces briefly the development and explains the operation and uses of Diesels. Along with the illustrations and discussions of operating features of the various F-M models, are given applications.

THE BOOKLET, "DRILLING CONTROL," completely describing the place of the "Quintuplex" in modern drilling, recently has been revised. The third edition is now being distributed. Copies may be obtained from the Martin-Decker Corporation, Long Beach, California.

MACWHYTE SLINGS, manufactured by the Macwhyte Company, Kenosha, Wisconsin, and used in heavy hoisting operations, are presented in a folder recently released by that company. The slings can be made with hooks, links, shackles, sockets, thimbles, and special fittings, in many combinations to meet individual requirements. A copy of the folder will be sent free upon request.

C. J. TAGLIABUE MANUFACTURING COMPANY, Park and Nostrand Avenues, Brooklyn, New York, announces the publication of a new Oil Testing Instrument Catalog, No. 699D. This book contains listings and descriptions, as well as technical information, on all oil-testing instruments, including thermometers, hydrometers, colorimeters, viscosimeters, flash and fire test apparatus, distillation apparatus, etc. In addition, will be found the New and Revised TAG Manual for Inspectors of Petroleum, as well as a complete set of charts for determining viscosity-index, comparing viscosities at various temperatures, blending and determining gravity corrections.

"VALVES FOR AIR-OPERATED CONTROLLERS," a 28-page illustrated bulletin published by The Foxboro Company, Foxboro, Massachusetts, provides a comprehensive review of controlled valves of both the throttling and quick-acting "open-and-shut" type, as well as modern controller accessories for extending the practical application of automatic control.

TYPE AE-1 AIR CIRCUIT BREAKERS, for industrial and central station auxiliary service, are described in a recent bulletin issued by the General Electric Company, Schenectady, New York. Copies will be sent free upon request.

AIR REDUCTION SALES COMPANY, 60 East 42nd Street, New York, N. Y., has issued a booklet presenting the story of Airco Acetylene, a copy of which will be sent free.

A DISTINCTIVE 96-page, 1936 edition of Data Book No. 125 on Silverstreak silent chain drives of fractional hp. up to 2000 hp., has been completed by Link-Belt Company. The volume includes installation pictures; engineering data; recommended drive selection; lubrication and casings; dimensions of chains and parts; list prices of chains and wheels; dimensions of wheel rims, hub sizes, bores, keys; chain adjusters; breaking pin hubs; electrical data, etc.

PATTERSON-BALLAGH CORPORATION, LTD., 1900 East Sixty-fifth Street, Los Angeles, California, has issued a bulletin describing its all-rubber drill pipe and casing protectors. Copies will be sent free upon request.

MAKE PLANS FOR INTERNATIONAL PETROLEUM EXPOSITION

PLANS for the next International Petroleum Exposition, to be held at Tulsa, Oklahoma, in May, 1938, were given impetus this month when the board of directors at the annual meeting called by President W. G. Skelly authorized the officers and executive committee to begin active promotion of the show.

Officers re-elected by the directorate were: Skelly, president of the Skelly Oil Company, president; Frank Hinderliter, president of the Hinderliter Tool Company, and Alf G. Heggem, president of the Oil Well Improvements Company, vice-presidents; Clyde Pape, secretary-treasurer of the Selby Oil and Gas Company, treasurer; H. R. Powers, manager of the Tulsa Chamber of Commerce Oil Industries Committee, was elected secretary. O. T. Dawson, vice-president of the National Supply Company, midwest, and W. M. Bovaird, president of the Bovaird Supply Company, were named to serve with the officers on the executive committee. W. B. Way is general manager.

Reporting a successful 1936 show to the directorate, President Skelly visualized an even larger exposition in 1938 with the probable addition of exhibits from allied industries such as the great automotive field.

Plans for new buildings and improvements to the plant were discussed and left to the officers to work out. Skelly said that he expected many more exhibitors to erect new permanent buildings of their own on the grounds for the next exposition.

General Manager Way said that despite the fact that no solicitation has yet been made exhibitors have written in reserving nearly two-thirds of the space now available on the 20-acre plant site. A large number of these have asked for increased space, he said, which may necessitate enlarging building facilities.

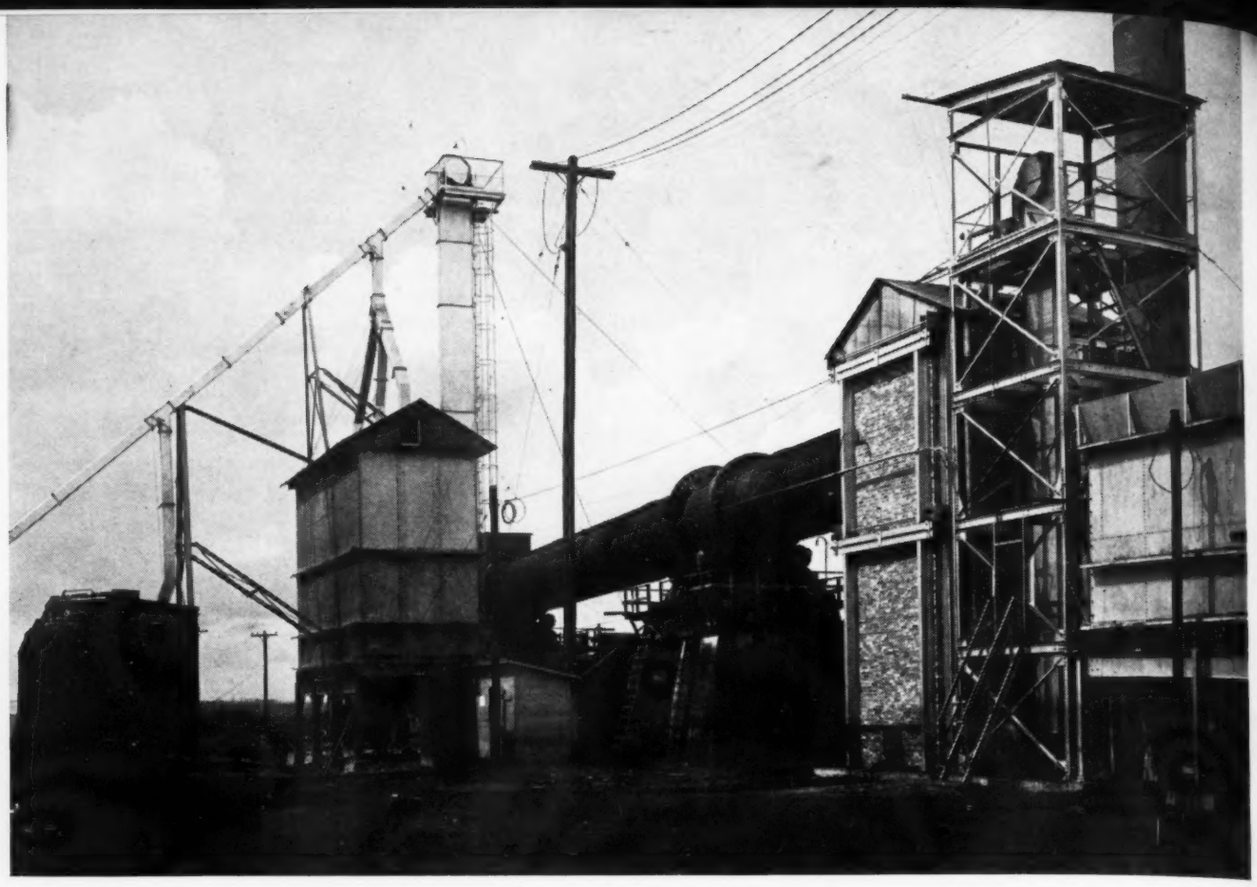
Although the price trend is upward, directors agreed to retain the same space rate, which was cut twice during the depression. Way said that the same service to exhibitors would be maintained for the May 14-21 exposition that has won the praise of manufacturers and supply houses in the past.

The Petroleum Engineer is planning to run a complete registration in connection with the 1938 Exposition. This will involve the badging of each attendant, giving name, company, and division of the industry with which he is connected. Complete plans will be announced in a later issue.

DIRECTORS AND OFFICIALS OF THE INTERNATIONAL PETROLEUM EXPOSITION WHO ATTENDED THE RECENT MEETING

From left to right, first row, Walter Gray, district manager Jarecki Manufacturing Company; J. Garfield Buell, independent operator; R. H. Bartlett, president, Union Wire Rope Corporation; Earl Sneed, Sneed Royalty Company; W. G. Skelly, president, Skelly Oil Company; R. S. Ellison, president, Stanolind Pipe Line Company; A. F. Bourne, secretary-treasurer, Oklahoma Iron Works; J. Burr Gibbons, vice-president, Rogers, Gano and Gibbons, Inc.; W. M. Bovaird, president, Bovaird Supply Company; Frank Hinderliter, president, Hinderliter Tool Company; J. H. Satterwhite, manager, Westcott and Greis.

Top row, Clyde Pape, secretary-treasurer, Selby Oil and Gas Company; Allmand M. Blow, vice-president, Amerada Petroleum Corporation; Hugh Stalcup, vice-president, Skelly Oil Company; Clarence Morris, publisher, The Petroleum Engineer; J. H. Brooks, vice-president, Republic Supply Company; William D. Moorer, president, Natural Gasoline Supply Men's Association; P. C. Lauringer, publisher, Oil and Gas Journal; Leon Booth, Selby Oil and Gas Company; H. R. Powers, oil industries committee manager, Tulsa Chamber of Commerce; Harry Krusz; Alf G. Heggem, president, Oil Well Improvements Company; W. B. Way, general manager; Clarel B. Mapes, secretary-treasurer, Mid-Continent Oil and Gas Association; Edward E. Robbins; Robert F. Garland, independent producer; Jay Walker, president, National Tank Company; L. S. Gregory, geologist.



Partial view of the coke calcining plant of the Great Lakes Coal and Coke Company at Port Arthur, Texas. The rotary kiln, 125 feet long and eight feet in diameter, is shown in the center. Coke enters the kiln through the chamber at the right, and passes through the kiln under terrific heat, which burns out impurities. From the elevator tower at the left the calcined coke slides down a spout to freight cars for loading, as shown, or farther on to a shipside warehouse for storing or placing aboard vessels

Conversion of Petroleum Coke Into Carbon

New plant at Port Arthur, Texas, makes possible a wider utilization of a by-product of the oil industry

By J. C. WATKINS

THE conversion of petroleum coke, through a calcining process, into 99 percent pure carbon and a form suitable for making artificial graphite, is being accomplished at a plant recently constructed at Port Arthur, Texas, by the Great Lakes Coal and Coke Company. The plant is one of two of its type in North America.

Utilization of this by-product of petroleum refining rescues it from the borderline of waste material and alters it into a form suitable for making carbon electrodes in arc lights, motion picture projectors, electric furnaces, aluminum reduction furnaces, dry cells, motor brushes, and many other industrial uses.

The calcining process removes the oil, gas, and moisture remaining in the coke and changes its characteristic from that of an electric insulator to that of a conductor.

Coke from the stills of oil refineries, is transported in gondola cars to the plant, where belt conveyors carry it to a screening plant that separates the smaller particles from the 2-in. and larger chunks, the latter being sold for metallurgical purposes, and for fuel.

The smaller pieces pass onto a conveyor belt and then go to a bucket elevator, which raises them to the upper end of the calcining furnace which is 125 ft. long and 8 ft. wide.

Into the lower end of this combustion chamber flames from gas jets are introduced, subjecting the coke to a terrific heat as it travels downward through the calcining chamber. This roasting process burns out the impurities.

When the red hot coke reaches the lower end of the furnace it drops downward through a brick chimney into a rotating cylinder, mounted on a slight incline. Passage through this chamber serves to cool the calcined coke.

Emerging from this cylinder, the material again goes up a bucket elevator and passes down a spout to belt conveyors, which carry it to a 125 ft. by 500 ft. warehouse where the finished product is stored for shipment. Belt conveyors beneath the floor carry the calcined coke to ships at nearby docks for loading.

The hardness and electrical conductivity of the finished material, which has undergone its chief change in the rotary kiln, make it useful for many products, some of which have been mentioned. This conversion of petroleum coke, marking the wider utilization of another by-product, serves to enhance the value of the industry.

W. E. Harvey is general superintendent of the Port Arthur plant, in which 50 persons are employed.

Death Takes D. C. Stewart

D. C. STEWART

D. C. Stewart, who directed the construction of the Magnolia Pipe Line Company's vast network of lines throughout the Mid-Continent area, passed away the latter part of January at his home in Dallas, Texas. Since 1931 he had been retired from active service.

Interesting Booklet by Andrew M. Rowley

Of interest to the petroleum industry is a 32-page booklet entitled "Oil Royalties Worth More Under New Methods" written by Andrew M. Rowley, 215 Calumet Building, Tulsa, Oklahoma, former editor of the Oil and Gas Journal, which has just come off the press and is ready for distribution by oil and royalty companies. Differing entirely from other treatments of the subject of oil royalties, the new booklet is a non-technical discussion of present-day policies and production practices that affect the income from, and the investment in, oil royalties.

Declaring that owners of oil and natural gas royalties are vitally concerned with developments and new methods and practices in the petroleum industry that affect their interests, Rowley says the purpose of the booklet is to explain in a manner that all may easily understand those features of present-day oil field operations that influence early and ultimate recovery of oil and natural gas from producing horizons. Among the subjects covered are proration, unitization, repressuring, water flooding, well spacing, geophysical prospecting, oil mining, acid treatment, cementing, and the use of mud-laden fluids. The booklet is well illustrated with photographs taken in different oil fields of the country.

Bureau of Mines Analyzes Sherman, Michigan, Crude Oil

THE crude oil produced from the discovery well in the new field of Sherman township, Isabella County, Michigan, has been analyzed by the United States Bureau of Mines, Department of the Interior, and found to be a paraffin base oil. The lighter fractions include 40 percent "gasoline and naphtha" and 20 percent kerosene distillate. The laboratory analysis (Bureau of Mines Hempel Method) indicates that these fractions are more paraffinic than the corresponding fractions from the oils produced in the other Michigan fields with the possible exception of the oil from the Trenton Lime horizon in Monroe County. It is interesting to note that the lighter fractions of this oil are more paraffinic than the corresponding fractions from the crude oils produced from the Cabin Creek, West Virginia, and the Rodessa, Louisiana, fields. The remaining distillates consisting of 23 percent gas oil and heavier distillates give indications that this Michigan oil would yield about the same type of commercial products as may be obtained from the Rodessa crude oil.

Although this well, Pure-Embrey No. 1, in section 34, T. 15 N., R. 6 W., is classed as the discovery well of a new field, it is only about one mile north of the Broomfield gas field. In 1934, a well, the Willie No. 2, in section 4, T. 14 N., R. 6 W., that had been producing gas from the Michigan Stray sand, was deepened to the Monroe formation. A showing of oil was found but the well was abandoned late in 1935. A deep test in section 3, T. 14 N., R. 6 W., later proved to be a dry hole. The extent of this newly-found area producing oil from a stratum considered to be in the Monroe formation has not yet been determined.

This oil, the analysis of which has not heretofore been published, was collected on November 11, 1936, from tanks at the flowing well, which is producing from a depth of about 3614 ft., after acidizing and plugging back from 3619 feet. The sample was obtained through the courtesy of the Geological Survey Division, Department of Conservation, State of Michigan.

The approximate summary of the analysis of the crude oil is as follows:

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	13.2	0.667	80.6	
Total gasoline and naphtha	40.0	.719	65.3	
Kerosene distillate	20.0	.792	47.2	
Gas oil	10.1	.830	39.0	
Nonviscous lubricating distillate	8.8	0.841-0.861	36.8-32.8	50-100
Medium lubricating distillate	4.7	.861- .871	32.8-31.0	100-200
Viscous lubricating distillate	—	—	—	Above 200
Residuum	14.3	0.902	25.4	
Distillation loss	2.1	—	—	

The detailed analysis of the crude oil is given below:

GENERAL CHARACTERISTICS

Specific gravity 0.788
Percent sulphur 0.40
Saybolt Universal viscosity at 77°F. 36 seconds
Saybolt Universal viscosity at 100°F. 35 seconds
A.P.I. gravity 48.1
Pour point below 5°F.
Color N.P.A. No. 5

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry distillation Barometer 752 mm. First drop: 24°C. (75°F.)

Temperature °C	Per-cent cut	Sum per cent	Sp. gr. of cut	°A.P.I. of cut	Viscosity at 100°F.	Cloud test °F.	Temperature °F.
Up to 50	3.7	3.7	0.634	91.7			Up to 122
50 - 75	3.7	7.4	.655	84.5			122 - 167
75 - 100	5.8	13.2	.696	71.8			167 - 212
100 - 125	7.2	20.4	.722	64.5			212 - 257
125 - 150	6.3	26.7	.739	60.0			257 - 302
150 - 175	6.2	32.9	.753	56.4			302 - 347
175 - 200	7.1	40.0	.765	53.5			347 - 392
200 - 225	6.2	46.2	.776	50.9			392 - 437
225 - 250	6.1	52.3	.791	47.4			437 - 482
250 - 275	7.7	60.0	.805	44.3			482 - 527
Vacuum distillation at 40 mm.							
Up to 200	5.0	5.0	.824	40.2	39	15	Up to 392
200 - 225	4.4	9.4	.834	38.2	45	30	392 - 437
225 - 250	4.5	13.9	.846	35.8	53	45	437 - 482
250 - 275	4.0	17.9	.855	34.0	77	60	482 - 527
275 - 300	5.7	23.6	.865	32.1	115	75	527 - 572

Carbon residue of residuum 2.2%. Carbon residue of crude 0.3%.

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Trade Personals

L. D. HILTON, sales manager of Cameron Iron Works, Houston, Texas, has returned to headquarters from a business trip that took him through the fields of Louisiana, Texas Panhandle, Oklahoma, Kansas, and New Mexico.

●

IRA B. YATES, general sales manager for the Wilson Welder and Metals Company, Inc., New York, recently made a trip through the Mid-Continent and Texas fields.

●

L. A. "PETE" CRAWFORD, representative of the Martin-Decker Corporation, has returned to his sales duties in the Mid-Continent and Gulf Coast areas after spending a vacation at the Martin-Decker plant in Long Beach, California.

●

L. C. RHOADS, Fort Worth district manager for the Hercules Tool Company of Tulsa, Oklahoma, recently returned to his office after a week's business trip through West Texas and New Mexico oil fields.

●

GEORGE C. MOON has been elected vice-president and a director of the American Chain and Cable Company, Inc., Bridgeport, Connecticut. He will make his headquarters at 230 Park Avenue, New York City.

●

JOE FULLER of Fort Worth, Texas, is now covering the entire Mid-Continent area on Fast couplings manufactured by Koppers Company, Bartlett Hayward Division, Baltimore, Maryland, the Houston district recently having been added to his territory.

●

C. C. CHRISTENSEN, refining specialist, Westinghouse Electric and Manufacturing Company, Petroleum Section, stationed at Dallas, Texas, recently was transferred to Kansas City, Missouri, where he is an industrial salesman.

●

B. F. KELLEY has announced his affiliation with the Shaffer Specialty Company, Tulsa, Oklahoma.

●

ERWIN A. WENDELL has been made district sales manager of Link-Belt Company with headquarters at 317 North 11th Street, St. Louis, Missouri. Wendell has been with the Link-Belt Pershing Road plant in Chicago. At St. Louis he succeeds HOWARD L. PURDON, who has been transferred to the company's Chicago plant to assume sales responsibilities in that territory.

●

B. J. BRUGGE, who spent two years superintending welding operations in the Near East, has been appointed to the sales staff of the Lincoln Electric Company of Cleveland, Ohio, and stationed at Los Angeles. W. R. SMITH, who has been employed in the welding field for ten years, also has been added to the Los Angeles sales staff. ROBERT L. WILSON, GEORGE MANDULA, and A. T. COX, JR., are additions to the Chicago sales staff of the company.

●

JOHN A. CHAPMAN, assistant general manager of Lucey Products Corporation, Tulsa, Oklahoma, was promoted to general manager and made a director at a recent meeting of stockholders. R. S. LEVERING, vice-president, also was made a director.

The Lucey organization also announces the appointment of LINUS L. MITCHELL as treasurer. He has been assistant treasurer.

H. EMERY GALBRAITH has been added to the field sales organization with headquarters at Gilliam, Louisiana.

Book Reviews

The East Texas Oil Field Directory (January, 1937, Edition). Compiled by Wimberly Report Service, Kilgore, Texas. Price, $2.00.

This volume is a classified directory of firms and individuals connected with the production, transportation, and refining of oil in East Texas. Included are contractors, supply companies, pipe line companies, refiners, producers, both independent and major, etc., cataloged in a manner to make them easily accessible. Addresses and telephone numbers are given. This latest issue of the directory has been revised and brought up-to-date by the publishers.

* * *

Geology of the Tampico Region. By John M. Muir. Published by The American Association of Petroleum Geologists, Box 1852, Tulsa, Oklahoma. London: Thomas Murby & Co., 1 Fleet Lane, E. C. 4. 280 pp. 61 illus. Bound in blue cloth, gold stamped, 6 by 9 inches. Price, $4.50 post free, $3.50 to A.A.P.G. members and associates.

An idea of the material contained in this volume is derived from the following condensed table of contents:

Part 1. Introductory. History. Topography. Drainage.

Part 2. Stratigraphy and Palaeogeography. Palaeozoic. Mesozoic. Tertiary.

Part 3. Igneous Rocks and Seepages. Asphalt. Oil. Gas.

Part 4. General Structure and Structure of Oil Fields. Northern fields and southern fields: Introduction, factors governing porosity, review of predominant features, production, description of each pool and field, natural gas, light-oil occurrences.

Appendix. Oil temperatures, salt-water temperatures, well pressures, stripping wells, shooting and acid treating, stratigraphical data in miscellaneous areas. List of wells at Tancoco.

* * *

Procedure Handbook of Arc-Welding Design and Practice. Fourth edition. Published by The Lincoln Electric Company, Cleveland, Ohio. 819 pp. 289 illus. Price, postpaid, $1.50 in the United States, $2.00 elsewhere.

The Procedure Handbook of Arc-Welding Design and Practice is reissued in greatly enlarged form and includes all new data essential for most efficient use of arc-welding in all its varied applications.

New data presented in the volume includes complete information on the following subjects: Characteristics of the welding generator, selection of type of joint, insurance of fusion welded vessels, welding codes, arc cutting, polarity of welding current, horizontal welds, sheet metal welding, effect of electrode size on welding cost, methods of testing weld metals, 4-6 chrome steel, monel metal, principles of surfacing by welding, welded design begins with standard shapes and plates, and plate girders.

In addition to this entirely new data, the handbook has been thoroughly revised in all its departments in light of present-day arc-welding practice.

Encyclopedic in scope, concisely written and profusely illustrated, the handbook is the complete reference guide for all who are interested in arc-welding. Written especially for use of designers, engineers, architects, production managers, welding supervisors, and operators, it contains a wealth of data of interest to draftsmen, steel fabricators and erectors, foremen, cost estimators, maintenance managers, shipbuilders, piping and pipe line contractors, and students of welding.

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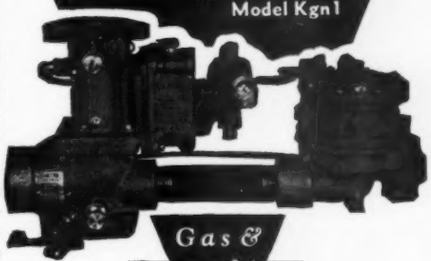

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J. A. Bermingham and F. C. Sealey Transferred

J. A. Bermingham, who has been vice-president and manager of production for The Texas Company of California, making his headquarters in Los Angeles, has been transferred to Houston as manager of production for the South Texas division. F. C. Sealey, who has been in charge of the South Texas division, has taken over Bermingham's post in California. The transfer of positions took place February 1st.

J. A. BERMINGHAM

Bermingham has been connected with the industry since the Spindletop boom at Beaumont, Texas, and has been associated with The Texas Company since 1927.

Sealey became assistant geologist with the Producers Oil Company in 1917, his first position in the oil industry. That company later became The Texas Company.

Plant Down But Two Weeks Despite Flood

Despite the severe flood the plant of the C. Lee Cook Manufacturing Company, Louisville, Kentucky, was shut down only two weeks. Operation was resumed on February 8 at full capacity.

Open Houston Office

Alco Products, Inc., opened a branch office at Houston, Texas, in the Esperson Building, on February 1st. John H. Erter, for many years in executive positions, will be in charge with R. W. Coghill as an assistant. E. J. Hudson, formerly sole Alco representative in the Texas territory, will continue his close relationship and coöperation.

Directory of Chemists

The American Association of Consulting Chemists and Chemical Engineers, Inc., has issued a 1937 directory of its members. In addition to the usual data found in a directory this one contains details concerning the work the members are prepared to undertake. The directory is being sent free to those making a request to the association at 50 East 41st Street.

Jones' Distributors List

The S. M. Jones Company recently published a small booklet showing the names and locations of all distributors of JonesSuckerRod stocks. Distributors names are arranged by states and then alphabetically by stocking points.

Johnston Testers Now Available in Mid-Continent

The Johnston Formation Tester is now available on the Gulf Coast. Service is being rendered by the Johnston Oil Field Service Corporation (a Texas corporation) with principal offices at 131 Harvard Street, Houston, Texas.

It is planned to establish service branches of this company in the near future throughout the major oil centers of the Mid-Continent.

Tube-Turns to New Quarters

Tube-Turns, Inc., Louisville, Kentucky, have moved from their old location at 425 Fifth Street to new and larger quarters at 224 East Broadway.

Awards Announced in Arc Welding Competition

One of the richest awards ever established for competition in the field of mechanical science has been announced by The James F. Lincoln Arc Welding Foundation.

To stimulate intensive study of arc welding, $200,000 will be distributed by the Foundation among winners of 446 separate prizes for papers dealing with this subject as a primary process of manufacture, fabrication or construction in 11 major divisions of industry.

The principal prize winner will receive not less than $13,700. Other prizes range from $7,500 to $100.

Contestants, it is announced, must have papers in duplicate on file with the secretary of the Foundation, at Cleveland, Ohio, not later than June 1, 1938. Prospective entrants should communicate promptly with Foundation Secretary A. F. Davis, P. O. Box 5728, Cleveland, Ohio, for complete details of the rules and conditions covering awards.

International Harvester Promotes Three

Three managerial promotions in the sales department of International Harvester Company have been announced. J. L. McCaffrey, former manager of domestic sales, has been made director of domestic and Canadian sales; W. F. McAfee, former manager of domestic motor truck sales, has been appointed to succeed McCaffrey as manager of domestic sales; and P. V. Moulder, former assistant manager of the Eastern district, succeeds McAfee as manager of domestic motor truck sales.

Johns-Manville Promotions

Promotion of four Johns-Manville officials to new executive posts has been announced by Lewis H. Brown, president, following the resignation of E. M. Voorhees, as secretary and treasurer, in order to accept the position of vice-chairman of the finance committee and a director of U. S. Steel Corporation. The promotions announced are: Charles H. Roberts from general auditor to comptroller; Arthur Olsen, who joined the company on January 1, to be treasurer; Vandiver Brown from assistant secretary to secretary; W. I. Waite has been made secretary of the officers' board.

H. F. Bishop Passes Away

H. F. Bishop, field representative for Baker Oil Tools, Inc., passed away January 22 at the age of 31. At the time of his death he was stationed at Lake Charles, Louisiana, having been transferred there from Houston about two months ago. He died in Houston when suddenly taken ill while attending a sales meeting.

Before joining the Baker organization two years ago, Bishop had been with The Texas Company in California, first in the capacity of petroleum engineer and later as drilling superintendent.

Acquire New Warehouse

The Charles N. Hough Manufacturing Company, manufacturers of oil well specialties, principally pumping equipment, with headquarters at Franklin, Pennsylvania, has acquired a new warehouse in Tulsa, Oklahoma, at 1-5 North Frankfort Street.

The company has six sales representatives in the Mid-Continent area, namely, C. O. Shumaker, Kansas; Frank L. Scott, Oklahoma; A. M. Mallinson, North Texas; Harry A. Adams, West Texas; G. A. Alviset, Gulf Coast; and Ed Ross, East Texas, Louisiana, and Arkansas.

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